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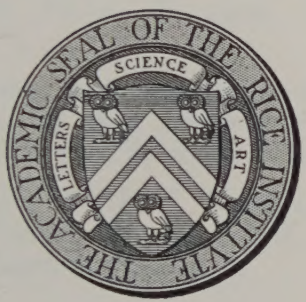

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PUBLIC LECTURES

I

BERKELEY'S CONCEPTION OF NATURE

DURING the reign of the English Queen Anne, a twenty-one-year-old Irishman in Trinity College, Dublin, wrote: "I do not pin my faith on the sleeve of any great man." It was not impudence in George Berkeley, born two hundred and fifty years ago, that moved him to say this. He lived in an age which, on the one hand, was witnessing the failure of the ideal of a united Christendom, and which in consequence inclined many cultured minds towards fatalism and atheism. On the other hand, the domain of abstract thought was then dominated by the works of the great philosophers Descartes and Locke. And in their dualisms of mind and matter lay the germ of scepticism. If there is a vast realm of material reality totally excluded from the realm of mind, how can mind know matter? In short, certain great men, because of their far-sightedness, had been content to view reality from a distance, and had thereby missed the fine detail in the picture. A closer view would have provided a corrective for false and borrowed preconceptions. Berkeley, modestly admitting his intellectual myopia,[1] claimed to have discovered something which greater genius had overlooked. He had to hold the object close to see anything, and he found the wherewithal to remedy the growing scepticism in religion and philosophy. Therefore,

[1] *Principles of Human Knowledge, Works,* Vol. I, p. 239 (Fraser's edition).

he was not willing to pin his faith on the sleeves of great men. He believed that, by their very greatness, they had raised a dust and thus set themselves and other people to complaining that they could not see. So, as a young mind "not yet debauched with learning," he assigned himself the task of clearing the atmosphere.

Everyone has heard the term "Berkeleyan Scepticism," and many believe that it properly names his philosophy. But those who catch the point and spirit of his thinking know that it is an absurd misnomer. Berkeley's main concern was not to establish scepticism, but to demolish it. And if in any sense he can be called a sceptic, it is the sense in which the person who doubts the existence of human quadrupeds is called sceptical. Obviously, if you take a man to be a rational quadruped, you must doubt the existence of man. This, as we shall see, is precisely the sense in which Berkeley is sceptical of the existence of a material world. Matter *as misconceived* is indeed dubitable. But such scepticism, being engendered by misconception only, is neither necessary nor natural. And Berkeley believed that the scepticism of his day was of this nature—something to which a natural end might be put simply by getting ideas of things as they are.

Now I am going first to describe nature as it was generally conceived in the English-speaking world at the beginning of the eighteenth century; indicating also the sceptical implications of this view. Then, beside it, I shall build up Berkeley's conception of nature. In the light of the contrast, I hope to impress you with the force of some of Berkeley's arguments.

The majority of reflective persons, under the spell of Newton and Locke, looked upn nature as a system of inert bodies existing in absolute space and time. These bodies are made up of small bits of dead matter called atoms and their properties are solidity, mass, motion, size, shape, abso-

lute place, absolute date, and number. In the course of their motion, they suffer impacts, and then *some* of them have sensations. Those having sensations are called "organisms." Sensations occur "in" these organisms or in the minds which permeate them. There are hot and cold sensations, sweet and sour ones, red and blue. These and the like exist only in the mind of the organism and represent nothing outside it. They are called "ideas" or "images." But there are also moving images, big and square ones, sensations of solidity, and the like. These in respect of their size, shape, motion, etc., though also existing in the mind, represent real physical properties of matter in the external world of nature, whose existence is in no way dependent on minds. By means of such ideas or images, we "know" the physical nature of things.

Now we shall imagine Berkeley asking Locke some questions concerning this view.

Berkeley: Why locate such qualities as color and sounds and smells in the mind and allow them to represent nothing?

Locke: Because they are relative to and dependent on the observing mind. Two persons looking at the same object would not get exactly the same color-sensation. Therefore color is not in the object but in the mind only.

Berkeley: But would two persons perceive exactly the same shape?

Locke: No, not immediately.

Berkeley: Then why not give shape the same status as color or sound or smell, making *all* perceived properties dependent on mind?

Locke: Because the real physical shape may be determined by reasoning.

Berkeley: Why cannot the real physical smell of a body be likewise determined?

Locke: I prefer you to ask me another question.

Berkeley: Good. Can you imagine a surface without any color whatsoever?

Locke: No.

Berkeley: Then when you speak of colorless surfaces of solid bodies, you have no idea of what you are talking about?

Locke: I have an abstract idea of it. Simply abstract the color from the surface by an intellectual act of analysis and what is left is the real physical surface.

Berkeley: But I find that when I mentally abstract the color, I take with it also the shape of the surface, since it is the outline of the patch of color which constitutes the shape. And surface without a shape is indeed a queer entity. One might as well argue that he has an abstract idea of square circles and that, though unimaginable, they exist in nature.

Locke: But we have sensory evidence of the existence of surfaces.

Berkeley: Not of *colorless* surfaces. Only of extended patches of color, or of warm or cold tangible surface. Now, I presume you have an idea of matter?

Locke: An abstract idea. When you mentally abstract all the qualities of matter, the x which is left as a bearer of these properties is matter. I confess I don't know what this material x is in essence.

Berkeley: Then what you directly perceive is not matter, but certain qualities only?

Locke: Yes.

Berkeley: If there is no sensory evidence for the existence of this unknown material substance, why in the name of heaven believe that it exists?

Locke: We must posit *something* as the external cause of the sensations in our minds.

Berkeley: To be sure, but why posit matter as you have

defined it? If matter is genuinely to cause anything, it must be active, and according to you it is completely passive and inert, even when in motion. Furthermore, will you explain how matter in motion causes a *sensation* in a living organism?

Locke: A sensation is somehow or other annexed to the motions of particles in the brain, but I cannot describe the details of the process.

Berkeley: It appears, Locke, that in positing the existence of material substance as you have conceived it, you have presented yourself with a white elephant. It is an *inactive cause,* it "causes" sensations in an unknowable manner, and is itself in essence unknowable. You are logic-bound to be a sceptic as regards the existence of material substance. And when I squeeze your "abstract ideas" of it for the juice of their meaning, not one little drop do we get out of them. Why not leave this theoretically useless substratum out of our picture of nature, and paint another one? Besides fostering scepticism in philosophy, your material substance breeds atheism in the field of religion. It is a brute, blind somewhat, unknowable and oppressive, filling man with a sense of being huddled about by thoughtless and careless natural forces. Perhaps we can portray nature more truly, not by excluding *matter* from the picture, but only what scientists and philosophers call material substance. . . .

Berkeley, at the age of twenty-five, and twenty-four years before he became Bishop of Cloyne in Ireland, did paint another picture, and a very beautiful one. Whether it represents reality—i.e., whether it is true—I shall let you judge. I propose now to exhibit Berkeley's conception of nature, developing it not exactly as he did, but in a manner calculated to draw sympathetic attention to what he took to be the most important points. Berkeley's world-view appears bizarre to him who simply stares at it unreflectively. Berke-

ley's readers and critics for a hundred years entirely missed the point of his philosophy, and, according to the general estimate, the speculative side of him was freakish—except in the medical part of his treatise on tar-water. The famous theologian, Samuel Clarke, would not even argue with him. When, thanks to his friend Swift, his philosophy of nature was introduced to English circles, a certain physician is reported to have become anxious about Berkeley's mental health. There is a story about Swift himself, according to which Swift, when Berkeley came to see him on a rainy evening, let him stand outside the closed door, since, if Berkeley were right about the nature of physical objects such as doors, he should be able to pass through them closed as readily as open. All of which shows how much Berkeley was misunderstood, and how important it is to strip ourselves of stiff preconceptions to be able to follow the lead of his supple and vigorous thinking.

Since Berkeley's doctrine is, in brief, that only minds and their ideas exist, that physical nature is nothing but a patchwork of ideas or sensations "in minds," we shall begin by a careful inquiry into the meaning of the phrase "in the mind," to show how conceivable, even reasonable, Berkeley's view is.[1]

Imagine your organism standing on an open plain and gazing across it at a blue range of mountains. You observe between your imagined body and the imagined mountains a distance of some sixty miles, and there are clouds which seem still farther away. Now if you were asked, where is this imagined scene, with its forms and colors, would you not say that it is in your mind, and that those clouds and

[1] Berkeley's failure to analyze and define the properties of the relation "in" where it is one of *mental* inclusion is a main weakness of his philosophy. See his comment in the *Principles, Works,* Vol. I, p. 284.

hills and plain and gazing organism have no reality outside your mind? I think you would, and I suspect the answer is in some sense true. Now open your eyes and perceive your own bodies, and the desk and the chairs before you, and the blackboard. Again there is a case of an organism gazing at something at a distance from it. But if you were asked where this second system of experienced objects exists, I take it you would deny that they are in your mind or in anybody else's. It is preposterous to suppose that these real physical things exist in minds. Their status, you argue, is absolutely non-mental. But what makes you think so? Is it because you perceive them at a distance from and outside your organism? If so, then why not say the imagined mountains are outside your mind, since they too were observed to be at a distance from your imagined organism. If it is highly conceivable that the whole imaginal situation is in the mind, why not the perceptual, also? The only difference between the imaginal and perceptual situations seems to be that the perceptual is a little more stable, a little more fixed. And that by itself is no reason to think it is independent of and outside the mind. Situations existing only in the mind may, for all we know off-hand, be as stable as you please.

This is the significance of the phrase "in the mind," as Berkeley uses it, and let us grasp it to begin with, even before we examine Berkeley's arguments to show that the material world is "in," and dependent on, mind. Otherwise, we too, are likely to look upon his whole enterprise as initially and finally freakish. We simply must not forget that, just as it is good sound sense to say that a vast panorama of *imagined* things exists in the mind, so the assertion that *perceived* things exist only in minds may also be far from absurd, and may even be true. *But,* someone may object, the proposition

that perceived objects are in the mind has queer implications. For example, when a man beholds the moon more than two hundred thousand miles away, does not his mind become more than two hundred thousand miles long, if this distance-interval is in his mind? By no means. *Imagine* yourself looking at the moon. Again you have the same distance between you and your object. And you admit that this whole imagined situation is in your mind. Does that imply that your mind must be as long as the imagined distance? No. Then, for all we as yet know, *perceived* distance may also be in the mind without odd consequences for mind, just as a sound-sensation is admittedly "in" the mind without making the mind itself noisy. We have first-hand evidence in the case of imagination that an apparently spatialized system of things may be in the mind without thereby causing the mind itself to acquire their spatial characteristics. The same may be true in the case of sense-perception. Indeed, there is a fund of evidence which purports to show that physical nature, as experienced in *sense-perception,* really does exist, without residue, only in mind.

Since we are already familiar with the arguments in favor of the doctrine that what is perceived depends upon perspective and that therefore perceived nature does not exist absolutely but only relative to this or that perceiving mind, I am not going to belabor the point here. Berkeley leans heavily on this argument from characteristics being what they are only relative to minds. Perceived mass, motion, change, shape, size, color, sound, etc., all depend on the point of view and the "frame of mind" to which they are given as objects of experience. Their "reference-frame" is always some mind. To try to conceive any one of them as being *the* real and absolute quality of a thing is to engage in the fruitless exercise of formulating an "abstract idea."

Rather than retrace these arguments step by step,[1] I shall sketch certain conclusions to which they directed Berkeley, particularly with reference to matter, space, and time. This will lead on to his theory of Divine Visual Language and of the relation of the physical world to God and ourselves.

We turn first to matter or to the meaning of the term "material thing." Perhaps you have already felt the urge to remark, in connection with Berkeley's wholesale relegation of perceived qualities to the realm of mind, that beyond this variable screen of sensory appearances lies a constant something which itself is not mind-dependent and to which the variable qualities are said to belong. Behind the fabric of shifting sensations or mind-dependent images —Berkeley calls them "ideas"—lies a constant extra-mental reality. And this, you say, is the realm of matter and of material things. Now Berkeley is willing to admit a reality behind sensory appearance, as we shall see, but he has good reasons for refusing to call it material, or a system of physical nuclei to which the perceived qualities are ascribed. Only one devastating difficulty which arises from such a conception need be mentioned. If these so-called material things exist outside minds, but all their perceived properties exist only in minds as has been proved, have you not an extremely queer divorce between qualities and the physical things they are said to qualify? And what could such physical things possibly be as divested of all known properties? There is no answer, and scepticism with regard to the nature and existence of physical things *as outside mind* seems to be the result. It is you, if you entertain this conception of matter, who must turn skeptic. But Berkeley is not willing to be sceptical about the existence and nature of material things. He is not going to think of men as quadrupeds and then be

[1] See *Three Dialogues Between Hylas and Philonous, Works,* Vol. I.

forced to doubt that there are men. Rather, he is going to investigate the status of physical objects more closely and get a notion truer than the old "abstract idea" of them, in the light of which new conception scepticism will lose its *raison d'être*.

A material thing, for Berkeley, is simply a "congeries" or collection of sensations and images, where "sensation" means something immediately sensed. Thus, physical objects are directly perceived by the senses. Instead of lying mysteriously behind sensory appearance, through which veil one must reach by the groping arms of inference, they are immediately exposed in sense-perception. For example, an apple is *nothing but* the round and the red and the cool and the sweet you become aware of when you see, touch, and taste it. Eventually, experience teaches you to associate, in imagination, certain other qualities with those directly sensed, such that when you merely look at a certain conjunction of the visual qualities "round" and "red", your imagination supplies the unseen qualities "sweet", "solid", etc., and you say that you "see" an apple; though all you literally see with your eyes is a patch of color in a certain light. This whole complex of perceived and suggested qualities is identical with the apple, and the material thing in this case is just this aggregate of qualities. But do not at least some of these qualities "belong to" some x, which latter is the physical object? Berkeley's answer is negative. Qualities refer to and connect up *with one another* to form a kind of system, but the whole system does not itself refer or belong to a material nucleus called the apple. The system of qualities is sufficient in itself to constitute the material thing.

Now, if such is the nature of physical objects, who can be doubtful about their nature or existence? That they exist, and what they are, becomes immediately evident in ordinary

sensory experience. Simply to be awake is to be convinced of both. *If* this is what "material thing" means, then indeed it may be granted that we know a good deal about matter and material things. But the new conception stimulates questions, which we shall ask Berkeley. It appears that physical nature is in one absolute space, and a public object of knowledge. But according to the view that material things are only sensations or ideas, nature is resolved into as many private worlds in private spaces as there are minds. Is not this absurd, that every mind contains its own little physical nature within itself, including the space in which that nature appears? Berkeley answers that there is indeed no absolute space. Stripped of all particular sizes, shapes, moving bodies, etc., space is nothing but a meaningless abstract idea. All immediately perceived spatial properties such as size and shape, together with distance and motion, are demonstrably relative to mind, and their relativity infects the whole of space. Berkeley is speaking psychologically here, and his opinion is confirmed by recent work in Gestalt psychology. And spatial magnitudes in perception depend on such qualitative factors as light and shade, etc., none of which is absolute. *Your* space is not *my* space, and neither you nor I have ever perceived a space including both. There may be something including us and others like us, but there is no evidence proving that this something is space. You must not assume that space is the only entity which can include things. Mind too is capable of including, though in a sense more difficult to define. For example, if you have an alert mind, it is "full" of suggestions. It contains or includes suggestions, though not as a drawer contains pieces of chalk. Is it not possible that the all-inclusive something which you mistake for space is a mind—the infinite mind of God in which we live, move, and have our being, much as,

for example, suggestions exist "in" our finite minds? We shall see later how Berkeley develops this notion. I mention it here for the light it throws on his conception of space. Minds are not in space, but spaces are in minds. Minds are not in skulls, but skulls are in minds. Hence, minds are not separated from one another by *spatial intervals* as skulls are, but by a kind of non-spatial otherness.[1] You cannot measure the interval between your mind and my mind by a yardstick. The interval between them is somewhat like the interval between two movements of a symphony, and that certainly is not spatial distance. Space with the clear-cut intervals it has as object of vision, turns out to be a "waking dream", to use a phrase Berkeley borrowed from Plato; and "high" and "low" even in the field of vision are ultimately as metaphorical as when applied to musical notes. Berkeley does frequently use the term *"real* distance", but such "distance" is never the object of sight and, upon analysis, resolves itself into the sort of non-spatial intervals which subsist between sensations in a temporal series. For example, the real distance of a fire seen as at about a mile from your organism is not this *visualized* interval, but rather is it the interval between a certain yellow color sensation—"seeing" the fire—and the sensation of warmth you have when, as you say, you "approach" the fire. And this interval between a color- and a temperature-sensation is obviously not visualized distance.

We have just used the adjective "temporal", and that raises the question of time. Is there an absolute, mathematical time, as Newton believed? Again Berkeley's answer is negative. Time is nothing but sequences of sensations in minds, hence there are as many times as there are minds. When a certain sequence of ideas or sensations is imme-

[1] Berkeley calls it "alterity". *Siris, Works,* Vol. III, p. 282.

diately *felt* as rapid, then real time literally "flies," since sequences of ideas *constitute* time. The notion of absolute time, moving with majestic regularity in all quarters of the universe, is the result of meaningless abstraction. The life of a fly is as long as the life of a man, if only the sensations in each creature are felt as constituting a considerable temporal span. Felt or sensed sequence is the only real time.

Let us ask Berkeley another question. Physical or perceived nature, as distinct from merely imagined nature, is regular, orderly, "cosmic" in the Greek sense of the word. To account for this fact, we are obliged to ascribe causal properties to material things, whereby one thing *necessitates* something else and thereby brings rational order into nature. Causation, as a system of physical forces *in material objects,* must be recognized. But, if physical objects are just collections of sensations, how can one thing be said to cause or necessitate something else, and what becomes of the uniformity of nature?

Berkeley is ready with an answer. Show me, he challenges, one case of *necessary* causal connection between material things or so-called events in physical nature. You will and can never find any such instance. The best you can do is to point to certain events which, so far as we know, have always occurred in conjunction. But this is no proof that they will continue to be thus correlated, or, in short, that the relation between them is one of necessary connection. We have never perceived any such relation in the physical world, such that natural uniformities must be traced to supernatural agencies. This fact of the absence of strictly causal relations between things recommends itself to us when we analyse, as we have done, the nature of material things. They reveal themselves to us, according to Berkeley, as wholly passive or inert complexes of sensations or percepts. We

never sense one sensation or group of such as acting upon another.[1] Not one of them is really causally operative, "making" others by its own agency. If Berkeley lived in our day, he might cite moving pictures as evidence of this thesis. It appears, on the screen, that certain things are acting upon others to make them behave as they do, but we know perfectly well that between one colored figure on the screen and another there is no real causal relation. So in ordinary perception of material things. These are made up of sensations, visual and non-visual, none of which really causes another. The whole panorama of physical nature is just a tissue of *effects,* in themselves totally incapable of activity.

It is interesting to think that the upshot of this view is in accord with the findings of quantum theory in recent physics, which asserts that between events in nature there is no real interaction, no strict or dynamic causation, but only correlations or coexistences, on the basis of which certain general averages are statistically obtained to serve as the "causal laws" of nature. Berkeley would have been delighted to learn that physicists, by their own machinations, had chanced across such a view of physical causation, with the category of *physical force* ruled out. This positivistic tendency in present-day science is what Russell had in mind when he said that modern physics is becoming less "muscular" and more "visual". Physical force is something the mind is tempted to read into material things, on the analogy of its own volitional experience of energy. But the cautious scientist, according to Russell and Berkeley, will content himself with mere correlations as laws of nature. Physics can get along without the concept of physical agency.

Now Berkeley has called nature a system of effects, and effects imply causes. Though there are no active causes *in*

[1] *De Motu, Works,* Vol. I, pp. 501-504, *et passim.*

physical nature, there are, he argues, active causes *of* physical nature. Genuine causal relations exist, not between material thing and material thing, but between mind and material thing. But obviously *our* minds have not willed or caused the existence of such things as a perceived river or mountain, though they may be responsible for a purely imagined one. What mind, then, is responsible for the perceived world called physical nature?

As we noticed before, Berkeley subscribes to the general belief in *something* behind sensory appearances, something other than our own minds, though he denies that it is matter. Behind or beyond the webs of cosmic appearances which constitute physical nature is not matter, but Spirit or Mind, and it is God's infinite mind. At last, we come to something genuinely capable of causal action on a grand scale. Of mind's capacity to act, we have immediate evidence in the case of our own minds. We are capable of willing, thinking, imagining, which activities produce the common effects we are all acquainted with. Mind can *do,* it can create. Just as, by our own volition, we can create images or a whole imaginary world, so God, by exerting his will directly upon us or causally affecting us by his divine activity creates the sensations in us which we call the physical world. This is the world we become aware of in sense-perception, and the reason for the prevailing belief in its permanence and public status is now clear. We ourselves are not the cause of physical nature. God causes it in our minds—in the previously defined sense of "in"—by operating upon us from without, in the non-spatial sense of "without". The uniformity of nature is simply the result of God's resolution or inclination to persist in certain general kinds of activity, affecting his creatures—us finite minds—by the same "powers" in his infinite mind, and thus establishing a unified society and a basis

for communication.[1] For example, if two of us should plan to meet a week hence at this hour, the eventual agreement between the two time series in the two minds involved would be due not to a single time-system common to both, but to God's having resolved to affect these minds with similar sequences of sensations of light and dark (day and night). And so there is cosmos instead of chaos, despite the fact that there is no single *physical* world which includes us all. What includes us all, in the peculiarly mental sense of inclusion, is the spirit of God, not inanimate nature.

According to Berkeley, you have less reason to doubt the existence of God than the existence of other finite spirits such as yourselves. This part of his argument is perhaps the most original, and sheds considerable light on his natural philosophy. If my presentation of it fails to win your sympathy, you may be sure that it is not Berkeley's fault. Berkeley said he wrote books not to force men to his conclusions but rather to make them think. The purpose of this lecture is to induce you to read Berkeley's works. You will find there, in *Alciphron,* a theory of divine visual language which will incline you to dwell with it in thought, with no sense of time wasted. I shall, in conclusion, commend this theory to your judgment.

What evidence have I of your existence not as a material thing but as a spirit or mind? The fact that I see what I call your face and apparently the light of speculation in your eyes does not demonstrate your existence as a spirit, but only as a material thing. I would experience a skillfully constructed robot in exactly the same manner. But if I do not take you to be a robot, it is because you address me in conventional symbols. You speak to me in words whose

[1] Whether one finite mind directly acts upon another is an open question for readers of Berkeley. See G. Dawes Hicks: *Berkeley,* p. 148.

meaning experience has taught me. You are capable of using a language significant by convention, to express your intentions and to otherwise inform me. That is why I believe that accompanying the complex of qualities I take to be your body is a mind and that this mind is essentially you.

Now notice the main characteristics of the language by means of which mind communicates with mind. In the first place, words rarely mean things by being similar to them. The written or spoken word "man", for example, is not *like* men or human nature. Similarity of sign and thing signified plays little or no part in linguistic symbolism. Secondly, there is no necessary connection between sign and thing signified. There is nothing in nature which logically or physically requires the visible or audible mark "man" to be conjoined with what it means. In the third place, language is a convention which minds institute by fiat of will. And fourthly, it must be *learned*. When you hear or see a Greek word for the first time, you do not know what it means. You must, by experience, learn the meanings of the words in any language.

If you will grant that anything which has these four characteristics is a language, Berkeley can prove that the whole of visible nature is a language, and the language of a powerful benevolent spirit which you should be willing to call God. I think we need take only one example to drive Berkeley's argument home.

When, as infants, we first saw a wavering yellow patch of color, we did not know what this color-sensation was or meant. So we put forth our hands to get a tactual sensation. The result was painful. We were badly burned. Thus we learned the meaning of the color or visual sensation, and came to recognize the whole complex of sensations as flame or fire. Later, the association in our minds of the color-

sensation with certain other sensations became so habitual that we said we could "see" the fire, though, in literal truth, we were visually aware only of a patch of color. We had so perfectly mastered the meaning of the visual sign that we began to confuse it with its various meanings, as we look straight through words to their meanings when we master some language. Furthermore, those visual sensations so regularly meant or accompanied the other sensations that we were inveigled into the belief that there was a necessary connection between them.

But let us stop to analyze the situation. Firstly, is there really a *necessary* connection between the yellowish patch of color and the sensation of being burned? It seems, rather, that we have simply closely associated the two ideas because they have so frequently occurred together. Analysis reveals that the occurrence of the one does not imply, by its very nature, the occurrence of the other. So one of the requirements of a language is here fulfilled: there is no *necessary* connection between the color as sign and the temperature or tactual sensation as thing signified. Secondly, did we not have to learn, by experience or practice, the meaning of the objects of sight? We did, and this satisfies another requirement of a language. Thirdly, is a visual sensation or color-patch similar to the non-visual sensations which it stands for? Plainly, it is not, and so we have here a third characteristic of a language, namely, no similarity of the meaning-term to the thing meant. The fourth characteristic, that language is a system of arbitrary[1] symbols established by fiat of will, also belongs to sensed colors, or to the immediate objects of vision. This may not seem so clear to us, but it follows from what Berkeley claims to have already proved. The colors

[1] Notice that though a system of entities is "arbitrary", it may nevertheless be regulated and orderly. Thus is visible nature at once arbitrary and systematic, dependable.

which our sense-perceptions of a mountain reveal are obviously not the result of our own volitional activity, nor of the will of any human spirit. Yet those color sensations must be the result of some volition or mental operation, since it has been shown that matter cannot produce mental phenomena such as sensations. Therefore, there must be, as author of the whole visible world of colors, some great Personality beyond it which produces visual sensations in us by fiat of will. The whole system of visible nature is, consequently, nothing but an arbitrary institution, a divine visual language, in terms of which God speaks to us. And the physical sciences, inasmuch as they formulate and generalize the correlations between our sensations, are simply the grammar of God's language.[1] Their function is to formulate its grammatical rules which we call "laws of nature", and thus make clear to us how the occurrence of certain things "means" the probable occurrence of certain other things. Even when the scientist peers through a microscope into what he calls a physical thing or event, he is simply acquiring a deeper insight into God's vocabulary by having new sensations. God then addresses him in novel terms whose meanings or correlations he learns by experience.

The divine visual language signfies in two dimensions: in the physical and in the spiritual. In the physical dimension, the meaning of the language instructs us as to physical consequences. For example, a red round visual sensation means that, if you will to proceed in a certain manner with reference to it, you will get cool and sweet sensations as a consequence, the aggregate of which qualities is, by us, called an apple. Or, a patch of yellow may mean that if you proceed thus and so, you will be burned. Thus God speaks in the physical dimension. But His language betrays His inten-

[1] *Works.* Vol. I, p. 318; Fraser's note.

tions, besides merely indicating physical consequences, and this is its spiritual or "affective"[1] significance. He who is concerned to tell you from your infancy that the result of certain modes of behavior is pleasant or painful must be a loving person or mind. And thus God tells us of Himself, that He is love, and so forth.

Clearly then, if Berkeley's theory of divine visual language is correct, we do have more evidence of God's existence than of the existence of each other, since all visible nature bespeaks the presence of God, whereas we betray our presence as spirits to each other only by comparatively few words. We read God's language everywhere and whenever our eyes are open, but we read or hear one another's language only during a small portion of conscious experience. And language alone demonstrates the existence of minds.

To put a finishing touch to Berkeley's conception of nature, I shall say a word in answer to the question, how does the physical world look to God, according to this conception of it? The answer, though difficult because not quite clear on Berkeley's own premises, is nevertheless important, since it requires us to put our fingers on the central nerve of Berkeley's philosophy of nature.

In one sense, God has no experience of a physical world. It does not exist for Him.[2] When God, as pure spirit or volitional activity, operates as He pleases upon us, then sensations in the narrow limits of *our* minds arise, and the panorama of these constitutes physical nature. We experience these sensations as a *physical* world, since, to us, they

[1] For the affective or "feeling" values of sense-data, see Hartshorne's comments on Berkeley: *Philosophy and Psychology of Sensation,* pp. 91-94.

[2] F. D. Mabbot in "The Place of God in Berkeley's Philosophy" (*Jour. Philos. Studies,* 1931, p. 18 et seq.) conclusively shows that Berkeley simply could not have meant to say that physical nature is perceived and supported by God's mind, as our finite minds perceive and support it.

are "objective" in the sense of not being the result of our own imagination. But nothing operates upon God, to give rise in Him to physical sensations. He is all-inclusive. Thus if God is aware at all of what *we* call the material world, He cannot experience it as material or objective, independent of His will. He is its creator. Hence it would seem that if He is in any sense aware of our sensations—and Berkeley is not clear about this—they must appear to Him as objects of imagination appear to us. God could change the whole *natural* scene by a mere act of imagination even as we can create in imagination what we please; and if He does not actually do so, it is because His divine nature is predisposed towards constancy. External to the realm of *our* imagination is the realm of sense-perception, the "real world" as we call it. But God knows the curb of no such external world. Everything is subjective to Him, in the sense of being the immediate product of His divine mind.[1]

Finally, Berkeley's conception of nature lies completely before us—complete, if we do not, as we shall not here, take into account *Siris,* a treatise he wrote in the evening of his life. The picture of nature we have surveyed is well conceived, but in many respects it is perplexing. This conception of a material world without material substance, of a physical nature existing as sensations only in the realm of mind, attracts a swarm of questions which vex us. Such vexation, however, being intellectual, is thoroughly wholesome, and I shall leave you with questions swarming about you. The exercise of clearing the air of intellectual flies develops the kind of muscles which may enable you to grasp

[1] At the very beginning (*Common Place Book, Works,* Vol. I, p. 60) and at the very end (*Siris, Works,* Vol. III, p. 289) of his intellectual life, Berkeley wrote that in the last analysis, only *persons* exist. "All other things are not so much existences as manners of the existence of persons." This is a decision in favor of God's point of view.

some new truth. And Berkeley, though convinced of the truth of his general theory of nature, wanted very much to make men think, whether or not they arrived at his conclusions. He succeeded so well in making men reflect for themselves that David Hume, born when Berkeley was twenty-six years old, developed, on a Berkeleyan basis, an argument which claimed to prove that, even as we have no *knowledge* of material substance, so are we ignorant of the existence of mind as spiritual substance. And both philosophy and science in our own day are reverberating with attempts either to refute or to prove Berkeley's argument that mind cannot be assigned a place in physical nature since the place of nature is in mind. Englishman Locke, Irishman Berkeley, and Scotchman Hume constitute a philosophical triangle whose properties are as eternal as those of any triangle in geometry.

VIRGIL C. ALDRICH.

II

CHARLES LAMB SEES LONDON

TO the visitor in London one practice may be commended if he would know the city: he should cultivate the habit of diving into the most unpromising alleys. For in London dingy and obscure things are not necessarily insignificant, and the past is just around the corner. Start an American tourist down the Strand, with or without a Baedeker, let him follow his nose to Fleet Street, and within half an hour he will have wandered down Middle Temple Lane, which stands for Charles Lamb, and up Johnson's Court, Bolt Court, and Wine Office Court, any of which lead to Gough Square, while all of these places stand for Dr. Johnson. Thus he will have spied out the modest though not contemptible quarters of the two great lovers of London. To these names a third should be added —that of Charles Dickens, but we cannot so easily fix Dickens to a particular spot, ensconced in chambers or in a coffee room—rather he wanders restlessly up and down a hundred shabby courts and squares. The old streets of London tell us that these men were of the earth, earthy; there is a touch of the street gamin, the imp, in Lamb and Dickens; as Dr. Johnson rolls his way along the pavement, we remember that he and Richard Savage once walked the streets half-starved, that he was once advised to get a knot and turn porter, that he exchanged derisive remarks with the watermen on the Thames, that Temple Bar and Covent Garden echoed to his laughter at midnight. All three of them

reached a fairer place than London town, but their feet were planted on her paving stones and their spirits were not smothered by her fog.

The London of Johnson, Dickens, and Lamb was neither mediaeval nor modern. The monuments of early times are more likely to be preserved in the provincial towns that are not trampled by crowds and smitten by the insidious changes of fashion and the fierce demands of progress. For the middle ages we go to the cathedral towns such as Ely, Wells, Canterbury, or Chichester, or to an unhurried market-town like Shrewsbury; nevertheless much more of mediaeval London might have survived if the Great Fire of 1666 had not swept away the old city from London Bridge to the Temple. Farther west, Westminster Abbey and Whitehall survived; at the eastern limit of the burned area stood the immemorial Tower of London, but from 1670 to 1800 most Londoners lived and worked in or near the new city that arose from the ashes of the Great Fire. Within this area Sir Christopher Wren built St. Paul's Cathedral, fifty-two churches, and thirty company halls, and his famous epitaph—"If you seek his monument, look around"—might be applied not only to St. Paul's but to the City at large. Wren's plans for a magnificent capital centering about the cathedral were never realized, and the spires of his churches overlooked crowded courts and squares, brought back to life for us in the pictures of Hogarth. Adjacent to the rebuilt area were a lawyers' quarter, extending from Gray's Inn and Lincoln's Inn to the Temple, and, north of the Strand, a region occupied by coffee-houses, taverns, theatres, and the great market of Covent Garden. This was in particular the London of the eighteenth-century hack-writers. Foreign visitors remarked on the heavy traffic and superabundant life in these densely

populated areas; the London citizen spent much of his time in public, and the same sights, sounds, and, it may be added, smells, were shared by all the generations from the early eighteenth to the mid-nineteenth century. Johnson, Lamb, and Dickens could all find their way about the same city, and this obvious truth may get added point if we pause to remember that Washington Irving would be hopelessly lost in the New York of O. Henry.

In spite of the crowds and the great size of London, the old city was not grandiose or magnificent. These simple facts sound more impressive in the words of Dr. Johnson: "Sir, if you wish to have a just notion of the magnitude of this city, you must not be satisfied with seeing its great streets and squares, but must survey the innumerable little lanes and courts. It is not in the showy evolutions of buildings, but in the multiplicity of human habitations which are crowded together, that the wonderful immensity of London consists." On his visit to Paris in 1822 Lamb remarked: "Paris is a glorious picturesque old city. London looks mean and new to it, as the town of Washington would, seen after *it*. But they have no St. Paul's or Westminster Abbey. The Seine, so much despised by Cockneys, is exactly the size to run through a magnificent street; palaces a mile long on one side, lofty Edinbro' stone (O the glorious antiques!) : houses on the other. The Thames disunites London and Southwark." The old City was not strikingly grouped, massed, or centered, although one might view Wren's clustering steeples from the Monument or the dome of St. Paul's. The general impression is well given by the satiric pen of Byron:

> A mighty mass of brick, and smoke, and shipping,
> Dirty and dusky, but as wide as eye
> Could reach, with here and there a sail just slipping
> In sight, then lost amid the forestry

> Of masts; a wilderness of steeples peeping
> On tip-toe through their sea-coal canopy;
> A huge, dun Cupola, like a foolscap crown
> On a fool's head—and there is London Town!

London was really an aggregation of towns, each with its own individuality. In 1700 one could name forty-six, besides the City proper and Westminster. This meant that the townsman could have his own retreat and pursue his tranquil way in the midst of the great ant-hill, and that a connoisseur of localities could notice endless interesting differences in the course of a mile's walk. The modern great city gives us the cruel contrast of slum and luxury, gaudy pleasure and ugly business. Such contrasts existed in the earlier London, of course, but it was after all the most middle-class of great cities. If I may pervert a line from Browning, "A common grayness silvered everything." Endless shops, taverns, and coffee-houses gave the town a certain homogeneity, without obscuring the eccentricities and "excellent differences" so dear to the Englishman.

The Temple was the center of Charles Lamb's life in London, and, we may add, the core of the reminiscences which are central for the essays. He was born in Crown Office Row, in the Inner Temple, in 1775, where his father was the confidential servant of an old bencher, Samuel Salt. In his own words:

> I was born and passed the first seven years of my life in the Temple. Its church, its hall, its gardens, its fountain—its river, I had almost said, for in those young years what was this king of rivers to me but a stream that watered our pleasant places?—these are of my oldest recollections.

Now the traditions of the Temple reach far back into the Middle Ages. After the Knights Templars came the lawyers in the fourteenth century, when, it is possible, Geoffrey Chaucer, as a student of the Middle Temple, was fined two shillings for beating a Franciscan friar in Fleet Street.

In the Temple Garden, according to tradition, were plucked the red and the white roses that came to symbolize the disastrous wars between York and Lancaster. In Middle Temple Hall Shakespeare's *Twelfth Night* was performed in February, 1602. But the Temple did not survive in Johnson's London merely as an odd anachronism. It blended easily with the newly built city of Wren; men such as Johnson himself, Blackstone, Fielding, Cowper, and Goldsmith lived and worked here. It was in and of the life of the Town, yet it offered a retreat from the din and traffic of Fleet Street. Other squares and courts, such as Gray's Inn and the Charterhouse, gave the same effect. Lamb's friend William Wordsworth lived in London in 1797, and wrote of his urban experiences in the seventh book of the *Prelude*. As we all know, Wordsworth was not entirely at ease in London, but no one has better described the quick transition from Fleet Street to the Temple:

> Meanwhile the roar continues, till at length,
> Escaped as from an enemy, we turn
> Abruptly into some sequestered nook,
> Still as a sheltered place when winds blow loud!
> At leisure, thence, through tracts of thin resort,
> And sights and sounds that come at intervals,
> We take our way.
> Private courts,
> Gloomy as coffins, and unsightly lanes
> Thrilled by some female vendor's scream, belike
> The very shrillest of all London cries,
> May then entangle our impatient steps;
> Conducted through these labyrinths, unawares,
> To privileged regions and inviolate,
> Where from their airy lodges studious lawyers
> Look out on waters, walks, and gardens green.

Professor Legouis has suggested that Wordsworth, writing these lines in 1804, may have been influenced by the impressions and sympathies of Lamb himself.

Let us go on to note briefly the places with which Lamb was closely associated. He went to school in Fetter Lane, a short walk from the Temple, and later he was a day pupil at Christ's Hospital, where Coleridge was his fellow-student. The pair of essays called respectively *Recollections of Christ's Hospital* and *Christ's Hospital Five and Thirty Years Ago* give us complementary reminiscences. In the earlier there is a touch of idealization: the boys go out merrily to swim in the New River near Newington; they enjoy free admission to the Tower; they eat splendidly in public; they wear a quaint costume of which they are very proud. In the later essay the boys return from bathing in the New River "faint and languid"; they go drearily for the fiftieth time to see the sights of the Tower; the food that is served them is abominable; the blue uniform of the school is a badge of slavery. Here pleasing recollections are dashed with that *amari aliquid* which every one not addicted to perfunctory sentimentalism must experience in trying to recover the impressions of early childhood. The country was also within reach, and some of Lamb's most vivid early recollections were of the old residence of his mother's kinsfolk in Hertfordshire. The home counties—Hertfordshire, Kent, Essex, Surrey—were not at that time cut off from the city dweller by long dreary miles of brick and pavement; one passed easily from the city into green fields. But for many years the Lambs lived in the heart of the town. They were in Little Queen Street, Holborn, in 1796, and there occurred the great tragedy which altered the course of Charles Lamb's life. His sister Mary, in a fit of insanity, killed her mother. Life went black for him, and he devoted the rest of his days to salvaging the wreck, to establishing as firm a footing as he could maintain for himself and his sister. For a few years they lived in the dull district of Pentonville, but in

1801 they returned to the Temple. "We can be nowhere private except in the midst of London," Lamb wrote to his friend Manning in that year. To the same correspondent he sent a description of his new lodgings that cannot be bettered:

I live at No. 16 Mitre Court Buildings, a pistol-shot off Baron Maseres'. You must introduce me to the Baron. I think we should suit one another mainly. He lives on the ground floor for convenience of the gout; I prefer the attic story for the air. . . . N. B. When you come to see me, mount up to the top of the stairs. I hope you are not asthmatical, —and come in flannel, for it is pure airy up there. And bring your glass, and I will shew you the Surrey Hills. My bed faces the river, so as by perking up my haunches, and supporting my carcase with my elbows, without much wrying my neck I can see the white sails glide by the bottom of the King's Bench Walk as I lie in my bed.

In 1809 the Lambs moved to Inner Temple Lane, scarce a hundred yards away. But upheavals of this kind were nothing less than cataclysms to people of settled eighteenth-century habits, and Lamb complains of the "dislocation of comfort." He writes to Manning in humorously elegiac mood:

Our place of final destination,—I don't mean the grave, but No. 2 Inner Temple Lane,—looks out upon a gloomy churchyard-like court called Hare Court, with three trees and a pump in it. Do you know it? I was born near it, and used to drink at that pump when I was a Rechabite of six years old.

(In passing, what a chapter of autobiography in that casual word "Rechabite." A Rechabite was under a vow to drink only water. Lamb had long ceased to be a Rechabite.) Poor Mary Lamb lapsed into one of her fits of insanity amid all this excitement, and Lamb was left alone in his new rooms, whence he writes to Coleridge in June; after some sad words about Mary he goes on:

The rooms are delicious, and the best look backwards into Hare Court, where there is a pump always going. Just now it is dry. Hare Court trees come in at the window, so that it's like living in a garden. I try to persuade myself it is much pleasanter than Mitre Court; but, alas! the

household gods are slow to come in a new mansion. They are in their infancy to me; I do not feel them yet; no hearth has blazed to them yet. How I hate and dread new places!

Complex moods, compounded of many simples, underlie these unpretentious words; one hesitates to expound passages like these, but perhaps we may venture to say, in heavy-footed comment, that Lamb makes a tragi-comedy out of the three trees and the dry pump in forlorn little Hare Court. They reappear—the trees have become four—in the essay called *Distant Correspondents:*

I am insensibly chatting to you as familiarly as when we used to exchange good-morrows out of our old contiguous windows, in pump-famed Hare Court in the Temple. Why did you ever leave that quiet corner?—Why did I?—with its complement of four poor elms, from whose smoke-dyed barks, the theme of jesting ruralists, I picked my first ladybirds. My heart is as dry as that pump sometimes proves in a thirsty August, when I revert to the space that is between us.

There was another migration in 1817, when the Lambs moved to Russell Street, Covent Garden. Actually they lived in the building that had once been Will's Coffee House, at the corner of Bow and Russell Streets, where Dryden and the wits had gathered a century and a quarter before; the building had by that time been divided into two private residences. Now they were in the midst of a hubbub; the market, the theatres, the life of the street, all before their very windows. Instead of complaining about the uproar they delighted in it; Mary wrote to Dorothy Wordsworth that she was learning to look out of windows again, and that the carriages coming to take up people after the play, with the "squabbles of the coachmen and linkboys," were a particularly fine sight. It takes more than ordinary zeal to enjoy Covent Garden now; the shabbiness has deepened, the grime has thickened, mud and fog predominate on many days of the year, though there is still the famous display of fruit and flowers in the market if one gets up early enough

to see it. There are still theatres in Covent Garden and in Drury Lane near-by, but time has dealt severely with this famous neighborhood, perhaps because there is no great piece of architecture, no insulated square or garden, to focus tradition and stir the imagination.

We may sum up this subject in the words of a note which Lamb contributed to the *Examiner* in 1813:

> Where would a man of taste chuse his town residence, setting convenience out of the question? Palace-yard,—for its contiguity to the Abbey, the Courts of Justice, the Sittings of Parliament, Whitehall, the Parks, &c.,—I hold of all places in these two great cities of London and Westminster to be the most classical and eligible. Next in classicality, I should name the four Inns of Court: they breathe a learned and collegiate air; and of them chiefly,
>
> those bricky towers
> The which on Thames' broad aged back doth ride,
> Where now the studious lawyers have their bowers;
> There whilom wont the Templar Knights to bide,
> Till they decay'd through pride—
>
> as Spenser describes, evidently with a relish. I think he had Garden Court in his eye. The noble hall which stands there must have been built about that time. Next to the Inns of Court, Covent-Garden, for its *rus in urbe*, its wholesome scents of early fruits and vegetables, its tasteful church and arcades,—above all, the neighbouring theatres cannot but be approved of. I do not know a fourth station comparable to or worthy to be named after these.

Old Palace Yard, in the shadow of the Abbey, is indeed a "classical and eligible" place, but it may be slightly surprising to find Lamb putting it at the top of the list. We have seen that he belonged after all in the City, not in Westminster. Perhaps we can find the secret of his preference in one of his whimsical enthusiasms: he delighted in the whole affair of the Gunpowder Plot, Guy Fawkes was one of his favorite villains, and I believe that he chose Old Palace Yard not just because one could easily step over to the Abbey or the Houses of Parliament, but because Guy Fawkes and some of his fellow-conspirators were most

properly executed there in 1606. With Lamb one must often allow for some underlying whim. The note which I have just quoted goes on to confess a prejudice, or, as he would call it, an "imperfect sympathy":

> To an antiquarian, every spot in London, or even Southwark, teems with historical associations, local interest. He could not choose amiss. But to me, who have no such qualifying knowledge, the Surrey side of the water is peculiarly distasteful. It is impossible to connect anything interesting with it. I never knew a man of taste to live, what they term, *over the bridge*. Observe, in this place I speak solely of *chosen* and *voluntary* residence.

But if Lamb had lived to read the *Pickwick Papers,* if he had witnessed the first appearance of Sam Weller as he polished boots in the courtyard of the White Hart Inn, or been present at the memorable supper which Bob Sawyer gave in his modest lodgings in Lant Street, he might have retracted his sneer at the old Borough of Southwark. And since we are speaking of prejudices, let me say that I should be willing to trade a file of the *American Mercury,* an unread novel by D. H. Lawrence, and a volume of short stories by one of our brightest young men, for one essay on Mr. Pickwick by Charles Lamb.

We must remember that during all these years Lamb was trudging eastward every day to his office, where he sat on a high stool and kept books. From 1789 to 1792 he was in the South Sea House, from 1792 to 1825 in the East India House, where, as he said, his "true works" might be found, "filling some hundred Folios." But it is the old South Sea House where he worked as a mere boy, not the East India House, which he immortalizes in one of the essays of Elia. To quote it would be to read it entire. The temptation to connect Dickens and Lamb is irresistible; their tastes in old city offices were somewhat alike. Both of them loved to describe the encrustations of time, the dust gathering in odd

corners, the doddering and eccentric clerks who dragged out their lives in these retreats. They let their imagination and humor play freely on the subject, innocent or oblivious of the fact that somehow, in these dingy holes, the business of a mighty commercial empire got transacted. Lamb, however, dwells fondly on the past; the East India House is mellowed by age, and the old clerks are delightful oddities. Dickens looks on the past as an incubus; the human spirit, indestructible, mercurial, incalculable, plays over and animates the decaying objects with a kind of life in death.

In 1820, evidently for the sake of Mary's health, the Lambs spent the spring and summer season in the suburb of Stoke Newington; this was the first of a series of suburban residences which the Lambs regarded as a kind of self-imposed exile. Mary expresses their feelings in a letter written in the spring of 1820 from Newington:

> It is so many years since I have been out of town in the spring, that I scarcely knew of the existence of such a season. I see every day some new flower peeping out of the ground, and watch its growth; so that I have a sort of an intimate friendship with each. . . . But flowers are flowers still; and I must confess I would rather live in Russell Street all my life, and never set my foot but on the London pavement, than be doomed always to enjoy the silent pleasures I now do.

About 1823 they gave up their rooms in town, and took a cottage at Islington, a suburb noted in the eighteenth century for its dairies, and for the tea-gardens where the citizens took their recreation on a Sunday. Here Charles discovered the suburban delights of gardening. In 1827 they moved still farther out, to Enfield Chase. Lamb explains to Thomas Hood the mode of life he planned at Enfield:

> Courtiers for a spurt, then philosophers. Old homely tell-truths and learn-truths in the virtuous shades of Enfield. Liars again and mocking gibers in the coffee houses and resorts of London. What can a mortal desire more for his bi-parted nature?

He made the region about Enfield his own; witness a charming topographical letter to Charles Cowden Clarke at the end of 1828:

> A sweeter spot is not in ten counties round; you are knee deep in clover, that is to say, if you are not a middling man's height; from this paradise, making a day of it, you go to see the ruins of an old convent at March Hall, where some of the painted glass is yet whole and fresh. . . . I shall long to show you the clump meadows, as they are called; we might do that, without reaching March Hall. When the days are longer, we might take both, and come home by Forest Cross, so skirt over Pennington and the cheerful little village of Churchley to Forty Hall.

Forty Hall is still in the guide-books, but not these other names. They have been lost in the spread of the great city, which unfortunately swallows up pleasant little detached places and intervening fields. As Mr. E. V. Lucas puts it, the Lamb country described in the letter to Clarke has been "built upon." But the pleasures of the country could not make up for the London Lamb had lost. It was a question of time rather than of space; the old city could not be recaptured by the simple expedient of traveling a few miles in a stage coach. Old friends and old sights were gone. In 1833 they both took refuge in a private asylum at Edmonton, where Lamb died in 1834. Meditating at his grave in Edmonton churchyard, the poet William Watson expressed the feeling that this rural spot was not an appropriate burial place for the city-lover Charles Lamb. Perhaps this discussion has not got far beyond the same commonplace—that Lamb preferred the city to the country. What is more interesting is that he sedulously fostered this idea; a history of his utterances on the subject will be of some value for the light it throws on his life, his literary friendships, and his development as an essayist.

Lamb appears in the 1790's as a satellite of Coleridge's, not much more eminent than forgotten minor men, such as

Coleridge's other associate Robert Lloyd. In the middle of the decade the talk, the enthusiasm, the generous ardor of these young men far outran their verse. Lamb and Coleridge used to foregather at the Salutation and Cat, Newgate Street; Lamb speaks of "that nice little smóky room at the Salutation, which is even now continually presenting itself to my recollection, with all its associated train of pipes, tobacco, Egghot, welsh Rabbits, metaphysics, and poetry." If we except the metaphysics and substitute gin for the egghot, this sounds much like the Lamb we know twenty years later. Some of the excitement of this period gets into the letters of the two friends, but they do not express it memorably in verse. Coleridge was in fact guilty of the "tumid ode and turgid stanza" for which Byron later derided him; Lamb inclined to mawkish effusions (a favorite word with the group) echoing the sentiments of William Lisle Bowles and William Cowper.

Now sentimentalists were expected to prefer the country to the town. Thus Lamb wrote in the summer of 1795, during a walk through the pleasant country of Hertfordshire:

> I turn my back on thy detested walls,
> Proud City, and thy sons I leave behind.

At first sight this appears to be utterly conventional. One might be tempted to cite the opening lines of Dr. Johnson's early satire *London,* in which he mourns the degeneration of the city and asks rhetorically,

> who would leave unbribed Hibernia's land,
> Or change the rocks of Scotland for the Strand?

Who would do all this? The answer would be, "Samuel Johnson himself." If some one asked him in later years—

I hope some one did—whether he really entertained the idea that it would be better to live in Ireland or in the Highlands of Scotland than in London, he might have snorted and answered that when a man is writing satire he is not upon oath. But to return to Lamb's sonnet—if we examine the situation closely we find that we have here not a mere piece of conventional sentiment. Lamb was suffering from the malaise that often overtakes a sensitive young man when he confronts an unfriendly world. The shadow of insanity was upon him; not long before he had been shut up for several weeks in a private asylum at Hoxton. Moreover, this sonnet and its sequel were inspired by an unhappy love affair, of which his biographers, perhaps fortunately, know very little. In 1802 he tried to explain away these early verses, and talked with some bravado of his "aversion from solitude and rural scenes." He continues:

> This aversion was never interrupted or suspended, except for a few years in the younger part of my life, during a period in which I had fixed my affections upon a charming young woman. Every man, while the *passion* is upon him, is for a time at least addicted to groves and meadows and purling streams. During this short period of my existence, I contracted just enough familiarity with rural objects to understand tolerably well ever after the *Poets,* when they declaim in such passionate terms in favour of a country life.

But this quotation takes us ahead of our story. The great crisis of Lamb's life came, as we have said, in September, 1796, when Mary Lamb killed her mother, and Charles Lamb found himself on the edge of the abyss. With the highest courage he wrought out a way of life for himself and Mary; he won through to independence and happiness. How he did this can never be exactly known to us. The biographer hasn't the evidence, nor perhaps if he had it would he have a right to put his own interpretation on it. There was a period of profound distress and uncertainty,

colored by religious feeling, which extends to the middle of 1798. Lamb's best known verses, "The Old Familiar Faces," written in that year, express his sense of the chasm that had opened between him and his past. For a time everything receded into the far distance, and Lamb writes as one old before his time:

> Ghost-like I paced round the haunts of my childhood,
> Earth seemed a desert I was bound to traverse,
> Seeking to find the old familiar faces.
>
> Friend of my bosom, thou more than a brother,
> Why wert not thou born in my father's dwelling?
> So might we talk of the old familiar faces.

Then comes a gap in the letters, and when we take up the thread again, at the end of 1799, we find the Lamb we know—poised, emancipated, meeting Coleridge and Wordsworth as equals. We shall see that he knits his present to his past again by his incomparable vein of pathetic and humorous reminiscence. In some sense he had rejected the spiritual aid and comfort offered by these friends, and carried on alone.

Now for our subject it is important to notice that the consolation Coleridge offered to Lamb at this time was the religion of the Lake School, the doctrine of the healing influence of nature. Innocuous as this doctrine may appear, Lamb could not accept it, at least in the spirit in which it was offered, and, significantly enough, from this period date his whimsical exaltation of London and his equally whimsical rejection of the romantic cult of rural life. In July, 1797, Lamb visited the Coleridges and the Wordsworths at Nether Stowey. This is the memorable occasion on which "dear Sara" [Mrs. Coleridge] spilled boiling milk on Coleridge's foot, so that he could not walk over the Quantock Hills with his friends. In their absence he wrote the lines

called "This Lime-Tree Bower my Prison," containing his tribute to Lamb:

> Now my friends emerge
> Beneath the wide wide heaven—and view again
> The many-steepled tract magnificent
> Of hilly fields and meadows, and the sea,
> With some fair bark, perhaps, whose sails light up
> The slip of smooth clear blue betwixt two Isles
> Of purple shadow! Yes! they wander on
> In gladness all; but thou, methinks, most glad,
> My gentle-hearted Charles! for thou hast pined
> And hungered after Nature, many a year,
> In the great City pent, winning thy way
> With sad yet patient soul, through evil and pain
> And strange calamity! Ah! slowly sink
> Behind the Western ridge, thou glorious Sun!
> Shine in the slant beams of the sinking orb,
> Ye purple heath-flowers! richlier burn, ye clouds!
> Live in the yellow light, ye distant groves!
> And kindle, thou blue Ocean! so my friend
> Struck with deep joy may stand, as I have stood,
> Silent with swimming sense; yea, gazing round,
> On the wide landscape, gaze till all doth seem
> Less gross than bodily; and of such hues
> As veil the Almighty Spirit, when yet he makes
> Spirits perceive his presence.

Noble lines, surely, but what is Lamb's response? He does not relish the compliment. His comments are vehement, quizzical, and even ungracious:

> In the next edition, please to blot out 'gentle-hearted' and substitute drunken-dog, ragged-head, odd-eyed, stuttering or any other epithet which truly and properly belongs to the gentleman in question.
>
> For God's sake (I never was more serious), don't make me ridiculous any more by terming me gentle-hearted in print, or do it in better verses. It did well enough five years ago when I came to see you, and was moral coxcomb enough at the time you wrote the lines, to feed upon such epithets; but, besides that the meaning of gentle is equivocal at best, and almost always means poor-spirited, the very quality of gentleness is abhorrent to such vile trumpetings. My *sentiment* is long since vanished. I hope my *virtues* have done *sucking*. I can scarce think but you meant it in joke. I hope you did, for I should be ashamed to think that you could think to gratify me by such praise, fit only to be a cordial to some green-sick sonnetteer.

Involved in these remarks are religious humility, a break with the sentimental cult of the 'nineties and the natural religion of the Lake School, and, I think we must add, a certain resentment at the patronizing attitude of the Lakers. Soon afterwards there was a temporary estrangement from Coleridge largely on these grounds. I detect to the very end a tendency to speak of "poor Charles Lamb." Coleridge, in the throes of the opium habit, deplores Lamb's unseemly association with William Hazlitt in those long evenings when Lamb and Hazlitt both smoked and drank gin, forsooth. Wordsworth could be mawkish enough to write in Lamb's memory:

> From the most gentle creature nursed in fields
> Had been derived the name he bore.

If Lamb heard of this tribute in the Elysian fields, I wonder, considering that he was a connoisseur in puns, what comment he stammered to the sympathetic shade of Sir Thomas Browne! Wordsworth and Coleridge were dearly esteemed friends of his to the last, but he could not surrender to them or abdicate his individuality.

His best defence was humor, and by 1800 we find him whimsically maintaining the thesis that London is good enough for him, let the Lakes of Westmoreland and Cumberland be what they may. As Lamb's able French biographer Derocquigny notes, a series of dithyrambs appears in praise of London in the letters of 1800 and 1801, and these are among the earliest of the richly humorous passages in his correspondence. All of them make direct and quizzical reference to Wordsworth and Coleridge. The longest is in response to an invitation from Wordsworth. It has often been quoted, but let us consider it again in its setting:

> . . . I ought before this to have reply'd to your very kind invitation to Cumberland. With you and your Sister I could gang any where. But

I am afraid whether I shall ever be able to afford so desperate a Journey. Separate from the pleasure of your company, I don't much care if I never see a mountain in my life. I have passed all my days in London, until I have formed as many and intense local attachments, as any of you mountaineers can have done with dead nature. The Lighted shops of the Strand and Fleet Street, the innumerable trades, tradesmen and customers, coaches, waggons, playhouses, all the bustle and wickedness round about Covent Garden, the very women of the Town, the Watchmen, drunken scenes, rattles,—life awake, if you awake, at all hours of the night, the impossibility of being dull in Fleet Street, the crowds, the very dirt & mud, the Sun shining upon houses and pavements, the print shops, the old book stalls, parsons cheap'ning books, coffee houses, steams of soups from kitchens, the pantomimes, London itself a pantomime and a masquerade, —all these things work themselves into my mind and feed me, without a power of satiating me. The wonder of these sights impells me into night-walks about her crowded streets, and I often shed tears in the motley Strand from fulness of joy at so much Life.—All these emotions must be strange to you. So are your rural emotions to me. But consider, what must I have been doing all my life, not to have lent great portions of my heart with usury to such scenes?—

My attachments are all local, purely local. I have no passion (or have had none since I was in love, and then it was the spurious engendering of poetry & books) to groves and vallies. The rooms where I was born, the furniture which has been before my eyes all my life, a book case which has followed me about (like a faithful dog, only exceeding him in knowledge) wherever I have moved—old chairs, old tables, streets, squares, where I have sunned myself, my old school,—these are my mistresses. Have I not enough, without your mountains? I do not envy you. I should pity you, did I not know, that the Mind will make friends of any thing. Your sun & moon and skys and hills & lakes affect me no more, or scarcely come to me in more venerable characters, than as a gilded room with tapestry and tapers, where I might live with handsome visible objects. I consider the clouds above me but as a roof, beautifully painted but unable to satisfy the mind, and at last, like the pictures of the apartment of a connoisseur, unable to afford him any longer a pleasure. So fading upon me, from disuse, have been the Beauties of Nature, as they have been confinedly called; so ever fresh & green and warm are all the inventions of men and assemblies of men in this great city.

Picture William Wordsworth reading this, and solemnly deprecating dear Charles's harmless prejudices. When Lamb actually visited the Lakes he was enchanted and abashed by the beauties of the region, but protected himself, so he said, by thinking of the ham and beef shop near St.

Martin's Lane. To the very last the thought of Wordsworth moved him to such utterances. In 1830 he wrote to his friend about the dulness of Enfield:

> O let no native Londoner imagine that health, and rest, and innocent occupation, interchange of converse sweet and recreative study, can make the country anything better than altogether odious and detestable. A garden was the primitive prison till man with promethean felicity and boldness luckily sinned himself out of it. Thence followed Babylon, Nineveh, Venice, London, haberdashers, goldsmiths, taverns, playhouses, satires, epigrams, puns—these all came in on the town part and the thither side of innocence. Man found out inventions.

So it came about that Wordsworth, in that excellent but somewhat priggish elegy which I have quoted, says rather heavily:

> Thou wert a scorner of the fields, my Friend,
> But more in show than truth.

Others among Lamb's friends played up to this prejudice, and Hazlitt compares Lamb in the country to "the most capricious poet Ovid among the Goths."

Lamb's letters are often a proving-ground for ideas which were later transferred to the essays. The earliest example of this which I have found is the use which he makes of the London passages of 1801 and 1802 in an essay written as the first of a series to be called *The Londoner,* published in February, 1802. But this early piece is not a full-fledged essay of Elia; the writer here follows the model of the eighteenth-century periodical essay, and talks for the most part as sedately as Addison. Lamb evidently felt that he was not in the right key here, for he did not continue to publish Londoners, and it was more than twenty years later that the essays of Elia began to appear in the *London Magazine.* The core of the essays is youthful reminiscence. Of the first series five, and those among the most famous, are set on such topics: *The South Sea House, Christ's Hospital Five and Thirty Years Ago, The Old Benchers of the*

Inner Temple, The Praise of Chimney-Sweepers, A Complaint of the Decay of Beggars in the Metropolis. All these, we may note, are the very cream of the essays; there is nothing in the second series to match them for topography and autobiography, except the incomparable *Old China.* Lamb's way of capturing the genius of a place is to identify it with his past self, and to set it forth in sudden glints of reminiscence. From Coleridge and Wordsworth he learned of the glory of childhood and the place of memory in poetry, though he would not be of their opinion about man and nature.

If we put Lamb in historical perspective, we see that in him the rich and coarse humors of the eighteenth century, set forth grossly and powerfully by Smollett and Hogarth, wire-drawn to mannerism and eccentricity by Sterne, were purged of their grossness and softened. Despite his love of all the sights and sounds of London life, he does not crowd his pages with faithful detail as does Gay in the remarkable set of verses called *Trivia, or The Art of Walking the Streets of London,* or as Hogarth does in his pictures; he does not give us an Aristophanic hodge-podge or a catalogue in the manner of Walt Whitman. He does not try to stem the full tide of life. Nor does he follow the newer mode of the romantic local colorists of his day, who systematically exploited the picturesque possibilities of places. For the difference, compare one of Washington Irving's London pieces in the *Sketch Book—London Antiques,* for example, with the treatment of the same subject by Lamb. Irving is consciously the tourist, underscoring the quaint and the antique. He may not pass this way again, so he tries to put all the stars and double stars into his own guide book. Even Scott follows much the same method in his delightful sketches of Edinburgh—neglected by the

modern reader—prefixed to the *Chronicles of the Canongate*. But Lamb is careful and parsimonious in his choice of details, invests them with humorous reminiscent lyricism, and sets them in a literary context.

His grotesques are Cockneyism transfigured. Consider how he transforms the humble chimney-sweeper. Dickens might have made of Lamb's chimney-sweepers a bold fantasy in black and white. Irving would have explained that chimney-sweepers are a part and parcel of Merry England, and might have added a note on Elizabethan chimneys. Lamb treats them at one moment in the spirit of a song of innocence by William Blake—"I have a kindly yearning towards these dim specks—poor blots—innocent blacknesses," and in the next he jumps to a literary analogy of exquisite mock-heroic quality:

> I seem to remember having been told that a bad sweep was once left in a stack with his brush, to indicate which way the wind blew. It was an awful spectacle, certainly; not much unlike the old stage direction in Macbeth, where the "Apparition of a child crowned, with a tree in his hand, rises."

We may say that childhood memory, the present and actual, and the contents of beloved books are on the same level for Elia. His London beggars are compared to illustrations in some collection of broadside ballads:

> The Mendicants of this great city were so many of her sights, her lions. I can no more spare them than I could the Cries of London. No corner of a street is complete without them. They are as indispensable as the Ballad Singer; and in their picturesque attire as ornamental as the signs of old London. They were the standing morals, emblems, mementoes, dial-mottoes, the spital sermons, the books for children, the salutary checks and pauses to the high and rushing tide of greasy citizenry.

But the best and most famous illustration of the way in which Lamb fused London and literature and reminiscence is in the superb passage of the essay called *Old China,* when

Bridget Elia (Mary Lamb) is speaking to her brother of the early days when they were happy and poor:

> Do you remember the brown suit, which you made to hang upon you, till all your friends cried shame upon you, it grew so threadbare—and all because of that folio Beaumont and Fletcher, which you dragged home late at night from Barker's in Covent Garden? Do you remember how we eyed it for weeks before we could make up our minds to the purchase, and had not come to a determination till it was near ten o'clock of the Saturday night, when you set off from Islington, fearing you should be too late —and when the old bookseller with some grumbling opened his shop, and by the twinkling taper (for he was setting bedwards) lighted out the relic from his dusty treasures—and when you lugged it home, wishing it were twice as cumbersome—and when you presented it to me—and when we were exploring the perfectness of it (*collating,* you called it)—and while I was repairing some of the loose leaves with paste which your impatience would not suffer to be left till day-break—was there no pleasure in being a poor man?

Lamb's London is a place where the contents of the folio Beaumont and Fletcher and the shop in Covent Garden where he bought it are on the same footing; if he goes to the play, the drama, the actors, and the theatre (that is, the playhouse itself) are of equal importance. In the essay *On Some of the Old Actors,* he tells us how one day he was walking in the gardens of Gray's Inn—superior even to his beloved Temple—where Bacon once walked before him, when he met the old actor Dodd, and immediately thought of all the comic parts he had seen Dodd play. The combination is characteristic of Lamb.

Lamb does not subordinate things and places to people, nor yet does he make people mere accessories to things and places. Rather he discovers a preëstablished harmony between the two; he submerges both in a common medium. We must borrow an illustration from Coleridge: as Lamb looked back at his old self and at the homely old places he knew, he found both invested with a strange charm, like that which moonlight gives to a familiar landscape. Coleridge used

this figure to describe the power of imagination; Lamb, instead of talking about imagination, dwelt on particulars and kept the whole transaction personal and private. His views of his own past, of the relations between people and places, are important instances of the odd scheme of sympathies and antipathies ("imperfect sympathies") which spreads like a subtle web through the essays. But all this analysis will be happily superseded if you will read Elia again and draw your own conclusions.

Alan D. McKillop.

III

SOME RECENT DEVELOPMENTS IN THE STUDY OF IMMUNITY

IT was, and in places still is, an old Chinese custom to wait until a child has survived an attack of smallpox before it is given full standing as a member of the family. When a local epidemic was in progress the delay would not be long, but if such an epidemic had recently occurred, killing off or immunizing practically the entire existing population of the town or village which was not already immune, it might be a number of years until a sufficient number of non-immunes had been born to support a new epidemic. So the astute Chinese hit upon the scheme of getting an inevitable ordeal behind him with as little unpleasant anticipation as possible by deliberately inoculating the child in its first year with smallpox pus taken from a case. But the Chinese showed his astuteness by inoculating from a mild case, probably having a deep-seated trust in the idea that like breeds like, even though the animate nature of an infection was an idea that developed centuries later. And he showed his astuteness further by performing the inoculation, unless pressed by an impinging epidemic, at a time when the child was in as good health as possible, avoiding times of famine, cold, heat, colic or other unfavorable conditions. The result was that, although there was an occasional unfortunate outcome, a great many babies were saved to ease the extra-terrestrial wanderings of their ancestors. The Chinese had, therefore, hit upon the most effective, although also the most danger-

ous method of immunization against disease, the method used by Nature herself—the inoculation of living germs. When we successfully survive an attack of smallpox, yellow fever, scarlet fever, or typhoid we are usually immune for life. Some diseases, however, leave less durable immunity behind them, and some almost none at all. The Chinese, however, improved on Nature's method of controlling (1) the virulence of the germs by taking them from a case in which they were not making very successful headway, (2) the site of inoculation, the skin resisting invasion longer than the mucous membranes, and therefore giving more time for the body to marshall its defences, and (3) the resistance of the host, so far as this can be influenced by good health and favorable environmental conditions. Of course the Chinese did not know why his inoculation saved his child while a natural attack so often killed it, but observation and experience left no room for doubt of the fact.

At the beginning of the eighteenth century smallpox inoculation had become a prevalent practice in Turkey, where the wife of the British ambassador, Lady Mary Montagu, in the face of an epidemic, having seen how successfully the practice worked, had her own son inoculated. Upon her return to England, where she saw havoc being wrought by the disease where no inoculation was practised, she endeavored as a patriotic duty to establish the custom there, but she brought down upon herself such an avalanche of antagonism, persecution, obloquy, and vexation that she sorely repented her patriotic efforts. Medical men unanimously predicted failure and disaster, the clergy ranted about the impiety of thus seeking to usurp the rights and privileges of Providence, and the populace were taught to hoot at the lady as an unnatural mother who had risked the life of her own child. Cotton Mather played the rôle of Lady Mon-

tagu in Massachusetts, and got much the same treatment. Gradually, however, smallpox inoculation took root both in England and America.

In the latter part of the eighteenth century there was an English country doctor named Jenner who got a bright idea. There was a tradition in the countryside where he practised that dairy maids who had had cowpox, which they contracted from the cows, did not take smallpox. Observation over a number of years led Jenner to believe that there was some truth in the notion and the idea occurred to him that the inoculation of cowpox might be used on a large scale as a preventive against smallpox. For eighteen years Jenner collected observations and data and then in 1796 he performed the first vaccination, using the term in the strict sense of the word. He inoculated a country boy with pus from a cowpox sore on the arm of a milk maid, acquired from the cattle which she milked. Two months later he inoculated the boy with smallpox and the boy failed to contract the disease. In his enthusiasm Jenner prepared a report on this one experiment for publication in the *Transactions of the Royal Society,* but it was rejected. In the next two years Jenner collected twenty-three cases of successful vaccinations, and published his results in a book of his own in 1798. A few people received the new idea with acclaim, a few opposed it violently, and the majority paid no attention. The anti-vaccination society, in essence, was born simultaneously with the publication of Jenner's book. Then as now it has been a favorite resort for the most fanatical of the people who by nature must be violently anti-something. Few anti-societies, with the exception of the anti-vivisectionists, can number among their members as many who are willing to put their intellects and reason so completely under the dominance of a single fixed idea. The early anti-

vaccinationists even suggested that cow-like features might develop on the persons of individuals inoculated with cowpox, although the chief objection was unwarranted interference with the activities of the Lord. However, in the one hundred and thirty-six years which have elapsed since Jenner published his work, what a change has been wrought! In the century following the death of Queen Mary II of England from smallpox the disease killed sixty million people in Europe. Today we still have smallpox, because too many people like to rely on the community protection afforded by their neighbors' vaccinations without adding their mite, but even so, I wonder how many in this room have ever seen a case of smallpox or have had personal knowledge of one? Jenner's discovery probably saved more human lives than have been saved by any other single discovery in medicine, for no one nowadays living in an all but smallpox-less civilized country, where he is protected by his neighbors' vaccinations if not his own, can fully realize the enormity of the change from pre-Jenner days.

The mechanism by which Jenner's discovery worked was not known till much later. Jenner thought that cowpox was a related disease peculiar to cattle which when inoculated into a man produced only a cowpox sore but gave immunity to smallpox as well. He was essentially right except that now there seems to be no doubt but that cowpox is nothing more than smallpox disarmed by life in a cow. The cattle were infected from their infected handlers, and uninfected handlers were in turn infected from the cattle, but meanwhile the smallpox germs had suffered so severely from their unhappy existence in the bodies of the cattle that they were never again able to regain their former exuberant vigor when returned to their proper environment in a human body, and instead of causing a respectable case of smallpox

were only able to produce a puny vaccination sore and sometimes had difficulty even with that. Yet, in the matter of developing resistance to them, the hosts reacted to these disarmed germs just as effectively as they did to the fully virulent ones.

So what Jenner did was merely to go the Chinese one step farther in controlling the virulence of the germs, by taking germs that were robbed of nearly all their power by life in a cow, instead of germs that were robbed of a little power by life in a resistant or convalescent individual, and by inoculation into a part of the body which offered relatively high resistance to them.

The next step was contributed by Pasteur in 1880. Shortly after he had proved that diseases were actually caused by living organisms, Pasteur was investigating chicken cholera and had numerous tubes of pure cultures of the organisms in his laboratory, which, when inoculated into chickens, produced chicken cholera. Then he went on a vacation for several weeks and left his cultures standing. Upon his return he put on his laboratory apron and began where he had left off, inoculating chickens in order to produce the disease and then find a cure for it. The old cultures, however, were no longer capable of producing chicken cholera, although he could still see living germs in them. Subsequently he got a fresh culture of his germs which would cause chicken cholera in previously uninoculated chickens but to his surprise the chickens he had tried to infect with the old cultures without success were now insusceptible to the fresh virulent cultures. No doubt many workers would have considered it a strange coincidence and promptly forgotten it, but Pasteur's mind was not satisfied with strange coincidences and he finally proved the true significance of what he had accidentally observed—that his cholera germs

had been disarmed but not denatured by a crowded life in a stagnant culture just as the smallpox germs were in a cow.

Pasteur was an enthusiast, and occasionally he let his enthusiasm carry him into the clouds. In this instance, having succeeded ingeniously in turning germs against themselves, he gave his imagination free reign and thought that perhaps his chicken cholera germs would protect chickens not only against chicken cholera but against other disease germs as well. To test this matter he inoculated some of his vaccinated chickens with anthrax, and when they failed to die he thought he was on the road to conquering all disease. It was not long until he found he was wrong, and that a vaccine can only be depended upon to protect against the kind of germs from which it was made. So he set out to find a way to disarm anthrax germs without taking from them their power to stimulate an animal to develop immunity to them. He succeeded by growing them at abnormally high temperatures, and measured the extent that he had weakened them by their ability, for example, to kill a guinea pig but not a rabbit, or a mouse but not a guinea pig. Then he inoculated the germs which had had their virulence reduced to mouse-killing proportions into some sheep, waited ten or twelve days and gave them a dose of the guinea pig-killing grade, waited another interval and gave them a dose of perfectly healthy unweakened germs that normally would have killed them in two days, and they remained perfectly well. Again Pasteur's imagination soared and he pictured himself finding successful vaccines for everything from itch to palsy, and said so to the Paris Academy of Sciences. That his proclamation should have been accepted with some skepticism is hardly to be wondered at; as a matter of fact it brought forth incredulity and derision. The upshot of it was that an arrangement

was made for Pasteur to put on a dramatic public demonstration under the auspices of an agricultural society near Paris. He was provided with forty-eight sheep, two goats, and several cattle. Publicly he vaccinated half of these animals, waited the desired length of time, and on May 31, 1881, inoculated all of the animals with a deadly dose of anthrax. On June 2, a huge crowd of scientists and laymen congregated and were awed to see how strikingly Pasteur had vindicated himself, for nearly all the unvaccinated animals were lying dead, and the few survivors were dying; but every one of the vaccinated animals was happily gamboling about. The acclaim which followed has probably never been equalled in the case of any other scientific demonstration.

Pasteur next turned his attention to rabies, and in spite of great difficulties succeeded in finding a way of taming the germ of this disease, although he never found it—by adapting it to rabbits, and then drying the spinal cords of the rabbits in which the germs were present. Thus was originated the Pasteur treatment for rabies.

It was natural that it should occur to someone that if attenuated germs could be disarmed without denaturing them too much to preserve their power of stimulating the body to react against them and thus develop immunity, dead germs might also be used. Experience has shown that this is only partly true. Most methods of killing germs at least partially denature them, so that they do not have the full power that living germs have of stimulating the development of immunity. However, if killed with a minimum of heat, they retain this power in some degree, much more so in the case of some germs than others. The most successful vaccination in which dead germs are used is that against typhoid fever. Before prophylactic vaccination, typhoid used to

kill more men than the enemy in armies in the field. In the Franco-Prussian War of 1870, sixty per cent of the entire German mortality was due to typhoid fever. In the Spanish-American War, in an army of 108,000 men, about one in five was attacked by typhoid, and there were sixteen hundred typhoid deaths. Since 1911, typhoid vaccination has been compulsory in the U. S. Army. During the World War with five million men in the army there is no record of the death from typhoid of a man who had completed his prophylactic vaccinations. One other type of vaccination is possible. Some germs produce their damage by secreting powerful soluble poisons, comparable in their nature to snake venom, but even more powerfully poisonous. By inoculating very minute doses of these toxins and gradually increasing the dose, immunity to the toxins can be developed, without establishing any immunity to the germs themselves, which, with their poisonous excretion stripped of its power, are of little consequence. Only a few germs produce their damage by means of these soluble toxins. The most important of these are diphtheria and tetanus. A modified toxin of the diphtheria germ is now very extensively used to protect susceptible school children against the possibility of infection.

The next question was the mechanism by which this immunity is brought about as the result of exposure to disease germs. In order to explain the facts of natural and artificial immunity, two theories were advanced and two separate schools of scientists arose in the last quarter of the nineteenth century to champion them. One was the "humoral" school whose article of faith was that immunity was due solely to properties of the body fluids, serum or lymph; this school was vigorously upheld by most German and some British workers, who assiduously performed innumerable experi-

ments and burned plenty of midnight oil writing about them, in an effort to support their stand. As a result they brought to light many very important and valuable discoveries, perhaps foremost of which was the discovery of antitoxins. The other was the "cellular" school whose guiding light was the great French biologist, Metchnikoff. Between these two schools the conflict raged for several decades, to the great advantage of the science of immunology, for the fire of combat continued to bring forth bigger and better experiments and demonstrations, until eventually the fight ended without a knockout; both sides scored many successful hits, but if a decision had to be made on points, I think most immunologist referees would raise Metchnikoff's hand. It is now generally conceded that whatever the immediate mechanism of immunity may be, a cellular response is the basic cause of it, and in very recent years it has become increasingly evident that immunity may exist entirely independently of serum antibodies, the presence of the latter being to a large extent an accompaniment rather than a cause of immunity. Serum changes are more easily demonstrable than cellular changes, and so it is not surprising that they should have had more importance attached to them than they deserve.

In the course of investigations on the mechanism of immunity it was found that when a body is invaded by bacteria or other foreign particles or substances, it reacts in one or more of a variety of ways. In the first place the serum may develop the power of neutralizing the poisons of certain bacteria or other organisms by developing antitoxins which combine with them. When these antitoxins have been developed in the serum of a horse, for instance, they can be transferred with the horse's serum to the blood of a man, in whom they afford protection just as they did in the horse. The injection of such an immune serum confers what is called

passive immunity because the recipient's own body has no more to do with its development than when quinine is injected to protect against malaria. If the person is inoculated with toxin, however, he in time develops his own antitoxin and this is called active immunity. Many people confuse serums, which confer passive immunity, with vaccines, which stimulate the development of active immunity.

It is only in cases where immunity depends on the presence of antitoxins that passive immunization, by injection of serum containing antibodies, has proved successful. In the early days of immunology it was hoped that it might be possible to prevent or cure any disease by the use of immune serum from an animal which had developed a very high degree of immunity, but these were false hopes. But in such diseases as diphtheria and tetanus, in which the damage is done by powerful soluble toxins, and in which the development of antitoxins is called forth as a response, the use of serum from immunized animals has been of enormous value. It is doubtful if any child stricken with diphtheria would die of the disease if antitoxin could be given within twenty-four hours, and most children can be saved if it is given in forty-eight hours. And in the case of tetanus, the use of antitetanus serum has almost abolished the disease. Tetanus is a wound infection, especially likely to develop in dirty, jagged wounds. During the great world war the routine injection of antitetanus serum to every wounded man reduced the death rate of these wounded men from nine per thousand to seven-tenths per thousand.

Another way in which the body reacts to invasion by bacteria is by producing in the serum the property of causing the bacteria to clump together or agglutinate. If, on the other hand, the invading substance is a fluid, e.g., foreign serum or egg white, the serum causes a fine precipitate to

develop in it. Under certain circumstances the serum develops the power of dissolving invading bacteria or cells. If white blood corpuscles are present the serum of the animal stimulates these to ingest and devour the invading cells or bacteria with greatly heightened avidity. And under certain circumstances a hypersusceptibility instead of immunity is developed to the invading substance; this is, for instance, what happens in hay fever. So at least six different kinds of antibody reaction are known, and until about twenty-five years ago it was generally assumed that there were as many different kinds of antibodies. Now, however, most immunologists find the problem complicated enough if they assume one or at most two kinds of antibodies, whose method of action depends upon accompanying circumstances.

Even this catalogue of immune effects is by no means complete. Some ten or fifteen years ago Taliaferro, at the University of Chicago, studied the course of infection in laboratory animals of certain Protozoa of the blood which we know as trypanosomes; it is one of these that causes the deadly African sleeping sickness of man. In the blood these parasites multiply by the simple process of longitudinally splitting in two, over and over again. Therefore as long as the host exerts no influence upon either the rate of reproduction or survival after being produced, and as long as they remain in the blood, their numbers should increase steadily by geometric progression. When certain kinds of trypanosomes are inoculated into mice this is exactly what happens; when the numbers have reached unbearable proportions the mouse dies. Taliaferro devised a method by which he could measure the rate of reproduction by means of a coefficient of variation in size. In rapidly reproducing trypanosomes the coefficient of variation was large, whereas when repro-

duction slows down or ceases the coefficient of variation falls. As would be expected in the fatal mouse infections the coefficient of variation remains uniformly high.

When certain other kinds of trypanosomes are inoculated into guinea pigs the numbers increase as in the mouse up to a certain point, whereupon the number suddenly falls to a very low point. Immediately the numbers increase again, and may again suddenly fall off, and so the infection proceeds by a series of crises and relapses. Throughout the infection the coefficient of variation, and therefore rate of reproduction, holds fairly steady. The sudden falling off in numbers is due to the production by the guinea pig of a trypanosome-destroying antibody in the blood which kills ninety-five per cent or more of the parasites, but for some unknown reason fails to get them all. It is as if a small percentage of a regiment, suddenly attacked by a deadly gas, were able to save themselves by getting their gas masks on in time. The survivors multiply at the same rate as before and therefore cause a relapse. The host then reacts by the production of a second type of trypanosome-destroying antibody, from which again a few may escape. Thus the infection goes on until eventually either the guinea pig succeeds in destroying them all, or else the parasites multiply too fast and kill the pig before a new destructive antibody is forthcoming. There is little doubt but that relapsing types of diseases, like relapsing fever, are due to this type of relationship between host and parasite.

Still a third type of response may occur, however. In the case of a trypanosome infection of rats which is very common in these animals, geometric increase in numbers takes place for about six days and then the increase falls off rapidly. The coefficient of variation indicates that by the tenth day reproduction is entirely inhibited. About this time

the host develops a trypanosome-destroying antibody and reduces the numbers to a very low point. Now, however, there is no relapse, for the parasites have lost their power of reproduction. After several weeks or months the non-reproducing survivors die out and the rat is thereafter immune. If in the meantime, however, some of these non-reproducing trypanosomes are inoculated into a fresh rat, they proceed to reproduce at the normal rate. On the other hand, if the serum from a rat which has developed the power to inhibit reproduction is inoculated into a fresh rat along with some healthy trypanosomes, no infection results, for the reproduction-inhibiting antibody can thus be passively transferred.

This power to inhibit reproduction without injuring the parasites may be a much more widespread phenomenon than is suspected. It particularly interests me because of some work which I have been doing with an intestinal worm, about which I will have more to say later, in which immunity is manifested first of all by a falling-off in egg-production, second by a stunting of growth of worms acquired later, and finally by a complete failure of the later-acquired worms to grow at all, although they show no evidence of injury. I cannot avoid the conclusion that in both of these cases the reason for the failure of growth and reproduction lies in the host having developed some means of starving the parasites to such a degree that they cannot grow or reproduce. The very fact that most parasites are so strictly limited to certain species of hosts, and to particular tissues of these hosts, suggests that they are very "choosy" with respect to the food they can assimilate, just as are certain insect larvae, which are able to nourish themselves only on the leaves of particular kinds of plants. They must have enzymes which make it possible for them to digest and assimilate the tissues

of the chosen host. If the host should develop anti-enzymes which would render these enzymes inert, we should have an adequate explanation for Taliaferro's non-reproducing trypanosomes, and for my non-reproducing, stunted or non-growing worms.

Within the last two or three years there has been a strong turn in the tide of opinion and of experimental evidence back towards Metchnikoff's cellular hypothesis of immunity, which leads one to think that, although Metchnikoff was wrong in entirely excluding the body fluids from participation in immunity, he did not go even far enough so far as the rôle of the body cells is concerned. Metchnikoff went at his problem in a sound biological way, and studied the nature of response to invasion of foreign particles in a whole series of animals from the single-celled amoeba to man. The single cell of which an amoeba is composed can perform all the necessary functions of life, including ingestion and digestion of foreign particles. But as many-celled animals develop and become more complicated, the cells become more and more specialized for particular functions, and only certain cells are set aside to retain the power of ingesting and digesting foreign particles. They are kept by the body to guard it against invasion, much as cats are kept by farmers to keep down rats and mice. Metchnikoff first observed the activity of these cells, for which he coined the term phagocyte (eating cell), in protecting water fleas from infection with a yeast-like invader. Later, in higher animals, Metchnikoff recognized two kinds of phagocytes, small ones which circulate in the blood as white blood corpuscles, and are mobilized at sites of infection by passage through the walls of blood capillaries to become pus cells; and large phagocytes, which may be fixed or free. Still later other investigators found that the body contained a whole system of cells called

the reticulo-endothelial system, belonging to the connective tissue class, but not too far modified, which have phagocytic power. They are concentrated in considerable numbers in the spleen, liver, lungs, lymph tissues, and walls of blood vessels. And now one is led to wonder whether the reaction of the body and consequent immunity is even limited to these cells. Besredka has done some very interesting work on the very striking affinity which certain invading organisms have for particular tissues. Anthrax, for example, has such a remarkable affinity for the skin and mucous membrane lining of the alimentary canal that, if these tissues are left uninjured, it is impossible to infect an animal even with enormous doses inoculated into the body cavity, or into the blood stream, or subcutaneously, or by any other route. But if a few bacteria are drawn back into the skin when the injection needle is withdrawn, a fatal infection results. The tissues which are insusceptible to infection are also insusceptible to vaccination and immunization. An animal cannot be protected by a vaccination which does not allow the inoculated bacteria to reach the skin cells. On the other hand, cutaneous vaccination by rubbing into a shaved skin, or injection into it, gives a solid immunity which completely protects the animal against infection, in spite of the fact that no antibodies can be found. Staphylococcus and Streptococcus also, although not so strictly limited to the skin, show a strong predilection for it, which suggested to Besredka that the skin would be the best place to produce immunity. In experiments on guinea pigs it was found that merely applying a wet dressing soaked in the filtered broth in which Staphylococcus had been grown to the shaved skin was sufficient to protect the animal from infection by an inoculation of the living germs under the skin twenty-four to seventy-two hours later. Besredka's results are not accepted at full

face value, but no one can deny that there is some truth in his contentions.

This whole question of local affinity of particular tissues for particular germs, and immunization by vaccination of these particular tissues is a very new and intriguing subject only the surface of which has been scratched. The older method of vaccinating in such a way as to produce serum antibodies without respect to the site of the susceptible cells, has on the whole given only moderately satisfactory results or none at all. If we could believe Besredka we would get better results if we started vaccinating against boils or impetigo by rubbing filtered staphylococcus or streptococcus broth into the skin, against typhoid and dysentery by drinking the killed organisms after preparing the intestine for their reception, against gonorrhea by washing the urethra with broth in which the gonococcus has grown, pneumonia by washing the lungs with pneumococcus filtrate, cerebrospinal meningitis by similar treatment of the spinal fluid, etc.

Nevertheless, until quite recently it was thought that the immunity of an animal to a bacterial infection resulting from exposure to this infection or to artificial immunization by vaccination was centered largely in the presence of antibodies in the blood serum and in wandering phagocytic cells. Recent work, however, has tended more and more to minimize the importance of circulating antibodies in the blood and to emphasize the importance of the cells in attacking and destroying not only bacteria but also other foreign substances such as serum of another kind of animal. Of outstanding interest is the work of Kahn, of the University of Michigan, who showed by some very ingenious experiments that when an animal has been inoculated with some protein substance like the serum of a different animal, not only its blood but some, if not all, of its body tissues, e.g., the skin,

acquire an increased power to combine with and in some way denature this protein. He found that when a rabbit is inoculated with a little human serum, after about two weeks the blood reacts perhaps a little better than the skin. But by the end of a month the blood will probably be entirely negative in its reaction while the skin reacts now as strongly as the blood did in the first place. When rabbits were inoculated by injecting typhoid bacilli into the skin, the skin showed a high reaction capacity and the blood a low one, and vice versa when the inoculation was made intravenously. In some other experiments Kahn showed that in some rabbits inoculated with horse serum the different tissues of the rabbits acquired the power to combine with and denature horse serum when subsequently injected, in the following relative proportions: to 75 units denatured when the serum was injected into the blood, 100 units were denatured when injected into the muscle or brain, 1000 units when injected subcutaneously or into the body cavity, and 1500 units when injected into the skin. In other words the reacting capacity of the skin and body cavity tissues to a protein substance to which the animal has been immunized is about ten times greater than that of the other tissues studied. This appears to be one of the most telling blows yet administered to the importance of the blood serum in immunity.

Another interesting piece of work which points to the local nature of immunity is an investigation by Blacklock and Gordon on the immunity developed by guinea pigs to invasion of the skin by an African maggot which parasitizes the skin of a number of animals including man. These authors showed that areas of the skin of guinea pigs could be rendered immune by the development of maggots in them, so that maggots subsequently applied, instead of developing normally, died within twenty to forty hours. They showed

that this immunity was not due to any change in the blood; the blood was shown to contain no parasiticidal properties, and injection of blood from immune animals failed to transfer immunity. The immunity was local in the skin; animals in which the skin on the back had been immunized could still be infected on other parts of the body, although the maggot-killing properties of the skin gradually spread over greater areas. Immune skin grafted on a non-immune animal retained its power to destroy the maggots and even spread its peculiar power to neighboring parts of the skin of the non-immune animal, but portions of the skin removed from the animal, and no longer living, lost its parasiticidal power. Furthermore when immune skin was penetrated by maggots, a violent skin reaction occurred which did not appear on the occasion of original penetration.

Some further evidence which detracts from the importance of serum antibodies and so-called general immunity—general because the blood reaches nearly all parts of the body—and emphasizes the importance and significance of a local response by the tissues which are exposed to attack, has been obtained in our own laboratory here. It has been conclusively demonstrated that animals which harbor worms in the alimentary canal soon become refractory to further infection, and show other evidences of acquired immunity. The problem we set ourselves was to discover something about the nature of this immunity and whether it was general, i.e., a property of the blood serum, or was purely local. In the carrying out of the experiments to get light on this I cannot speak too highly of the very efficient and valuable assistance which I have obtained from Miss Evelyn Kuhn.

Our experiments were made with white rats infected with a small intestinal worm found in wild rats. We first immunized some rats with a series of superimposed infections

with this worm, then inoculated previously uninfected rats with liberal doses of serum from these immunized rats, and then infected the rats, along with some control rats which were injected with serum from normal rats, and also some which received no serum. A study of the results convinced us that the serum from the immunized rats had no effect whatever on the course of the infection in the rats to which it was given. We then undertook a still more conclusive experiment. We joined pairs of rats together after the fashion of Siamese twins, so that there was a very good blood connection between the two, the blood of one, with whatever immune properties it might contain, freely intermingling with the blood of the other. One of the members of these pairs of rats, either before or after being joined to its mate, was given repeated infections with an intestinal worm until it showed complete or partial immunity to further infection. Then its mate, which had never been infected, was exposed to infection with the same worm and the development of the worms in these rats was compared with the development in normal, previously uninfected rats. In these experiments the immunity that had been acquired by one of the members of a pair, if it were general and had become a property of the blood, would inevitably have been conferred upon the mated rat which shared the same blood. But no such thing happened; the worms developed in the previously uninfected mate quite as readily and as normally as they did in normal rats. I think this leaves no room for doubt but that in this particular instance the immunity exhibited against reinfection with an intestinal worm is purely local and dependent upon some change in the mucous membrane of the intestine. The nature of the change is problematical, but the facts suggest that the effect is a nutritional one. To reach their habitat in the intestine the larvae of this particu-

lar worm go on a roundabout "homeseeker's" tour in the rat's body. From their site of inoculation under the skin they enter the circulatory system, by which they are carried to the heart, whence they are pumped out to the lungs. Here they are caught in the capillaries, burrow into the air spaces of the lungs, are propelled up the trachea to the throat and then, if lucky, are swallowed, thus reaching their destination in the alimentary canal. In immunized rats larvae inoculated under the skin arrive in the intestine in approximately normal numbers and in a normal length of time. After arrival there, although they fail to grow or develop, they remain active and apparently healthy until expelled from the intestine, never showing evidence of being affected by any injurious or lethal action on the part of the host. It would fit the observed facts to suppose that the enzymes which the worms use to digest the host cells in order to obtain nourishment are rendered ineffective in an immunized host by the development, in the cells of the mucous membranes, of anti-enzymes. If the production of such anti-enzymes spread from cell to cell, eventually all or a large part of the mucous membrane might become immune, thus making it impossible for young worms to establish themselves. The idea of a failure of nutrition of parasites due to the development of anti-enzymes by the host would explain a number of other phenomena that parasitologists have observed, and may have rather far-reaching implications which have not yet been considered. At any rate it is a matter which seems well worth further investigation, which we hope to give it in our laboratory.

Asa C. Chandler.

IV

THE SCIENTIFIC WORK OF MADAME CURIE

THE discovery of the element radium by Madame Curie in 1898 and the investigation of its properties profoundly modified nineteenth century conceptions about matter and electricity. Up to about 1890 the classical Newtonian theory was unchallenged and some scientists thought that no new fundamental discoveries were to be expected. Then came Roentgen's discovery of X-rays, J. J. Thomson's discovery of electrons, Curie's discovery of radium and polonium, Planck's quantum theory of radiation, Rutherford's nuclear theory of the atom, Bohr's theory of spectra, and Einstein's theory of relativity, and the whole classical Newtonian conception collapsed.

During the nineteenth century the atoms of the chemical elements were thought of as hard particles, those of any particular element all exactly alike and indivisible. The radioactive atoms were found to disintegrate spontaneously, a radium atom splitting up into a helium atom and a radon atom. Thus the conception of the elementary atoms as indivisible, indestructible particles was proved untenable. The atoms are not hard, indivisible particles, but are complicated structures built up out of smaller particles. These discoveries opened up a new field for investigation, namely, that of the structure of atoms, which has ever since occupied the foremost place in physical science.

Marie Sklodowska was born in Warsaw in 1867, and she married Pierre Curie, who was a professor of physics in

the Sorbonne, Paris. In 1896, in Paris, Becquerel found that uranium emits penetrating rays similar to X-rays, and Madame Curie immediately became interested in this new phenomenon and began experimental work on it. She found that certain minerals containing uranium were several times more strongly active than pure uranium. This suggested to her that these minerals must contain substances besides uranium more active than pure uranium. Madame Curie and her husband then obtained a large quantity of the residues left after the commercial extraction of uranium from uranium minerals and proceeded to search for new radioactive bodies in them. They found two new elements, radium and polonium, which are several million times more strongly radioactive than uranium. From about one ton of the residues they finally got about one ten millionth of a ton of pure radium chloride.

Radium is a white metal like silver, but it tarnishes readily in air. Its chemical properties are very similar to those of the well known element barium. It has a characteristic spectrum, an atomic weight of 226, and all the ordinary properties of a metallic element. It is usually prepared and sold in the form of radium bromide, which is a white crystalline salt easily soluble in water. Radium is very costly because the process of extracting the minute amounts present in uranium minerals is long and complicated, and the demand for medical purposes is greater than the supply. The market price at present is about fifty dollars per milligram of radium element, or at the rate of twenty million dollars for one pound. Some hospitals have half a million dollars' worth of radium in use for the treatment of cancer.

Radium is remarkable because it disintegrates or decomposes spontaneously into a series of new bodies which emit peculiar radiations. A quantity of radium therefore slowly

diminishes in amount, so that it is calculated that about half of it will disappear in sixteen hundred years.

The radiations emitted by radium and its decomposition products are of three distinct sorts, namely, alpha rays, or helium atoms charged with positive electricity which are shot out with velocities of about twenty thousand miles per second, beta rays, which are negative electrons with velocities up to one hundred and eighty thousand miles a second, and gamma rays, which are very penetrating rays similar to X-rays.

The investigation of the products of decomposition of radium and the other radioactive elements and of the radiations which they emit has been going on now for over thirty years, but is yet far from complete, and new discoveries continue to appear in this fertile field of research. In this long series of investigations Madame Curie and her associates played a leading part.

The discoveries of radioactivity by Becquerel and of radium by Madame Curie were of such striking scientific interest that the investigation of the new phenomena was immediately taken up by physicists and chemists all over the world. Many new discoveries about radioactivity were made independently at almost the same times by different scientists, so that it is sometimes difficult to be sure who first announced a particular result.

The rays emitted by radium can be detected in several different ways. For example, they affect a photographic plate like light and they cause air to become a conductor of electricity. If a small quantity of radium is put near to a charged electroscope the air is made to conduct and the electricity on the electroscope rapidly escapes. With polonium instead of radium there is no effect unless the polonium is within about two inches of the electroscope.

Polonium emits only alpha rays, which are stopped by about two inches of air. This experiment with polonium was first done by Madame Curie soon after she discovered it. Alpha rays can be easily studied with C. T. R. Wilson's cloud expansion apparatus. This consists of a cylinder with a glass top, inside which a piston can be moved up and down so as to compress and then rarefy the air in the cylinder. If there is a little water in the cylinder so that the air is saturated with water vapor, then when it is caused to expand quickly by suddenly moving the piston down, the air is cooled and the water vapor tends to condense into a cloud or fog of small droplets. These droplets form on minute dust particles in the air and if there are no dust particles the droplets do not appear. When an alpha ray goes through the air it collides with the air molecules and knocks electrons out of them so that it leaves a track of electrons and positively charged molecules. These charged particles act like dust particles and cause the water vapor to condense so that we get a visible track of water droplets. In this way we can make the paths of the alpha rays visible as thin, nearly straight tracks which can be photographed. An alpha ray is just a helium atom, so that we are able to see and photograph tracks made by single atoms. The beta rays also make tracks in the expansion apparatus, but much thinner ones than the alpha rays. The gamma rays themselves do not make tracks, but they knock electrons out of atoms and these electrons make tracks like beta rays.

The rays are found to be emitted when a radioactive atom disintegrates or decomposes into two new atoms. Thus radium atoms disintegrate into radon atoms and helium atoms, and the helium atoms are the alpha rays. Radon is a gas and its atoms disintegrate into helium atoms and new atoms called radium A atoms. Radium A then gives a

series of new bodies and finally lead remains. Besides this radium series of radioactive elements, several other similar series are now known. All these different bodies have different properties and disintegrate at different rates. The subject of radioactivity is now a large and important branch of physics which is very active at present.

Let us now consider in more detail Madame Curie's more important contributions to the subject. Her greatest discovery was that of radium in 1898. She separated the radium from Pitchblende[1] and finally obtained pure radium chloride. No other strongly radioactive element has been prepared pure in appreciable quantities. The separation of pure radium from Pitchblende was an extraordinarily difficult operation, or rather long series of operations. It was possible only because of the radiations emitted by the radium which enabled minute amounts to be detected and measured. Thus the chemical fractions of the material could be classified according to their radioactivity and the activity gradually concentrated.

About the year 1900 Madame Curie determined the atomic weight of radium by an exact analysis of pure radium chloride, finding it equal to 225. The latest value of this important constant is 226, so that Madame Curie's first determination was within one half of one per cent of the true value.

Madame Curie showed that radioactivity is an atomic property. She found that the activity of compounds of radioactive elements depends only on the amount of the active element present and is not affected by the nature of the other elements with which the active element is combined. Also she showed that the activity is not affected by changes

[1] The uranium mineral from which the residues used by the Curies were derived.

of temperature or other physical conditions. These results were important in that they pointed towards the correct theory of radioactivity, namely, that it is due to atomic disintegrations and not to any sort of ordinary chemical change.

Besides radium Madame Curie also discovered another radioactive element in Pitchblende which she named polonium in honor of her native land, Poland. This element was found along with bismuth in the chemical fractions and could not be separated completely from it. Madame Curie found that the radioactivity of the impure polonium gradually diminished so that after four months it had only one half its initial value. This was a fundamentally important result because it showed that a radioactive body gradually disappears. The atoms disintegrate or decompose into new bodies which may or may not be radioactive. It has since been shown that all radioactive elements disappear in this way, some very slowly and some more rapidly. For example, radium slowly disappears so that it will be half gone in sixteen hundred years, and radon, one of the disintegration products of radium, disintegrates so that half of it is gone in four days. This means that out of say 1024 radon atoms only 512 are left after four days, 256 after eight days, 128 after twelve days, 64 after sixteen days, and so on. Any particular radon atom may last for a hundred days or more, but on the average half of the atoms disintegrate every four days. The disintegration is not affected by physical or chemical conditions; it is a property of the radioactive atoms. The atoms are all exactly alike, but they do not last equally long. The 32 atoms left out of 1024 after twenty days behave just like the original 1024, that is, half of them disappear every four days. We may say that the expectation of life of a radioactive atom is independent of its age. A radon atom always has a one in two chance of

four more days of life however old it may be. What particular atoms disintegrate during any interval appears to be purely a matter of chance, whatever that may mean. Suppose a small quantity of a radioactive element is emitting say one hundred alpha rays per second, then the average interval between the rays is one hundredth of a second, but the intervals are not all equal. A few will be as great as one tenth of a second, or as small as one thousandth of a second. Madame Curie measured the intervals between the emissions of single alpha rays by a small amount of polonium during several months and showed that they are just what would be expected if the emissions are determined just by chance.

During the nineteenth century it was supposed that all material particles obeyed exact laws of nature so that nothing happened by chance. This idea has proved untenable, and we now suppose that the laws of nature do not determine exactly what will happen, but that they merely fix the relative chances of various possible events. The disintegration of radioactive atoms with the emission of alpha rays is an example of this sort of thing. The laws of nature do not require an atom to disintegrate at any particular time; they merely fix the chance that it will disintegrate in a given interval. An atom of radon has a one in two chance of disintegrating in any interval of four days, but it may last for years.

Radioactive disintegration provided one of the first examples of the statistical character of natural laws, so that its discovery and investigation by Madame Curie helped to start a profound change of a very general character in our ideas as to the nature of the physical world.

In 1903 Madame Curie, working with a colleague, Laborde, discovered that radium generates heat continuously,

so that it is always hotter than surrounding bodies. They found that radium produces enough heat to raise the temperature of an equal weight of water to the boiling point in about one hour. This heat energy is mainly the kinetic energy of the alpha rays which are stopped by the radium itself and by the walls of the vessel containing it. Since radium disappears so slowly that half of it remains after sixteen hundred years, it must contain an enormous store of energy much greater than that set free by any chemical reaction. During the sixteen hundred years one gram, or one-twenty-eighth of an ounce of radium generates enough heat to boil ten tons of water.

Working with her husband, Madame Curie discovered that radium causes any substance kept near it to become temporarily radioactive. This effect, called induced radioactivity, is due to the gas radon which radium emits. The radon gas disintegrates into a series of solid radioactive elements of short life which are deposited on bodies with which the radon comes in contact.

Madame Curie and her husband, Pierre Curie, were awarded a Nobel Prize for the discovery of radium and polonium, and a new Chair was founded at the Faculty of Sciences of Paris for Pierre Curie. Most unhappily Pierre Curie was killed by an automobile in 1906 and Madame Curie succeeded him in the new professorship. She continued her researches on radium and made many more important discoveries.

An international congress of physics was held in 1910 with Madame Curie presiding. This Congress adopted a new scientific unit which was called a "Curie" in honor of Madame Curie, and denotes the amount of radon in equilibrium with one gram of radium. A millicurie and a microcurie are respectively one thousandth and one mil-

lionth of a curie. Madame Curie was requested to prepare an international standard of pure radium chloride, which is kept along with the standard meter at St. Cloud, near Paris. This radium standard is used to determine the amount of radium metal in any preparation of radium. The intensity of the penetrating gamma rays from the standard is compared with the intensity of the same rays from the preparation by methods developed by Madame Curie. The Bureau of Standards in Washington has a radium standard which has been compared with Madame Curie's international standard. When radium is sold in the United States, the specimen is sent to the Bureau of Standards and compared with the Bureau's radium standard. In this way the purchaser can be sure of the exact amount of radium that he gets.

Soon after the discovery of radium, it was found that the radiations from it have powerful physiological effects. They produce serious burns on the skin, destroying the tissues. The treatment of cancer by radium radiations was later developed and proved to be valuable in many cases. For such treatments radium itself need not be used. The gas radon emitted by radium may be sealed up in a small glass tube and used instead of the radium. Thus the valuable radium may be kept in a safe place and only the radon from it used in treating cancer. The radon tubes can be sent by mail to patients anywhere. The activity of the radon tubes drops to one half every four days, so that it becomes very small after a few weeks, but it lasts long enough for the cancer treatments. The radium generates fresh radon all the time, so that new tubes can be prepared to replace the old ones which have lost their activity.

During the war Madame Curie had charge of the Red Cross X-ray service. She equipped many X-ray cars and

drove several of them to the front. She also got over two hundred X-ray outfits for war hospitals, helped greatly with the actual X-ray examinations of wounded soldiers, and established a training school of Radiology for nurses. In 1916 she developed, in Paris, a center for the distribution of radon tubes for medical purposes, using her whole stock of radium for this. In all this war work she was assisted by her elder daughter, Mlle. Irene Curie, now Madame Curie-Jolliot, who is also a prominent physicist.

Two laboratories were established in Paris soon after the discovery of radium, for research on radioactivity. These laboratories are known as the Radium Institute, and Madame Curie gave to this Institute all the radium which she and her husband extracted from Pitchblende. Later she gave to the Radium Institute the gram of radium presented to her by the women of the United States. Associated with the Radium Institute is the Curie Foundation, built and endowed by Henri de Rothchild, who gave to it half a gram of radium. These laboratories are devoted to research work on radioactivity, including medical applications, and they supply radon tubes for cancer treatments in French hospitals.

Madame Curie's scientific work was universally recognized as of outstanding merit. She received innumerable honors and awards from universities and scientific societies throughout the world. She was awarded a second Nobel Prize, and so had the distinction of being the only scientist ever to win more than one. During the war she gave up research and worked for France in every way possible. She died on July 4, 1934, of anaemia due to radioactive radiations. Shortly before Madame Curie died her daughter announced the discovery of artificial radioactivity, a discovery comparable in importance with that of radium. Ma-

dame Curie and her daughter are the only women who have ever made scientific discoveries of first rate importance. Just as Faraday's discovery of electromagnetic induction led to all the modern applications of electricity which have profoundly changed human civilization, so Madame Curie's discovery of radium has started a series of scientific events which will ultimately result in changes equally great.

Madame Curie was a great experimenter, and she developed a chemical technique for the study of radioactive elements. The workers in her laboratories are equipped to investigate problems in radioactivity rapidly and efficiently by her methods. Thus her example and her point of view inspire the workers in her field. The science of radioactivity advances rapidly and new discoveries of extraordinary interest appear almost daily, largely because of the foundation so well laid by the discoverer of radium.

Radioactive elements spontaneously transform themselves into new elements, and the study of radioactivity has led to the artificial transmutation of one element into another. Just as chemists are able to make new compounds of old elements, so physicists may now make new elements. So just as we expect the chemists to produce all sorts of new compounds with valuable properties, so we may now expect the physicists to produce new elements with new properties.

There has never been a more exciting time for physicists and chemists than the present. If only scientific research is not destroyed along with civilization, but is allowed to go on under favorable conditions, no limits can be imagined to the results to be expected, and no branch of science seems to have greater promise for the future than radioactivity.

H. A. Wilson.

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